APRIL, 1937 25 Cents

THE TECH ENGINEERING NEWS

IN THIS ISSUE

The Coaxial Cable

The New York World's Fair

The New Universe

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Checkmates Corrosion

Welding aids modern metallurgy to produce completely corrosion-proof assemblies

EQUIPMENT is subject to corrosive attack and consequent deterioration by three forces: chemical attack, electrolysis and erosion. Chemically active gases, liquids, pastes, or solids eat away the more easily attacked portion. Dissimilar metals often set up galvanic currents, which cause pitting and corrosion. High-velocity steam or solid particles in a slurry add mechanical abrasion to the ravages of chemical and galvanic attack.

Welding Prevents Deterioration

Welding is a valuable aid to users and fabricators of equipment for corrosive service. By welding, equipment can be made smooth, jointless—one-piece. Valves and necessary fittings can be faced with corrosion-resistant metal welded in place. Chemical attack can be further prevented by making welds of material similar to the body metal.

Welded assemblies present a smooth, unbroken internal surface. No pockets are formed in which concentration and consequent deterioration can occur.

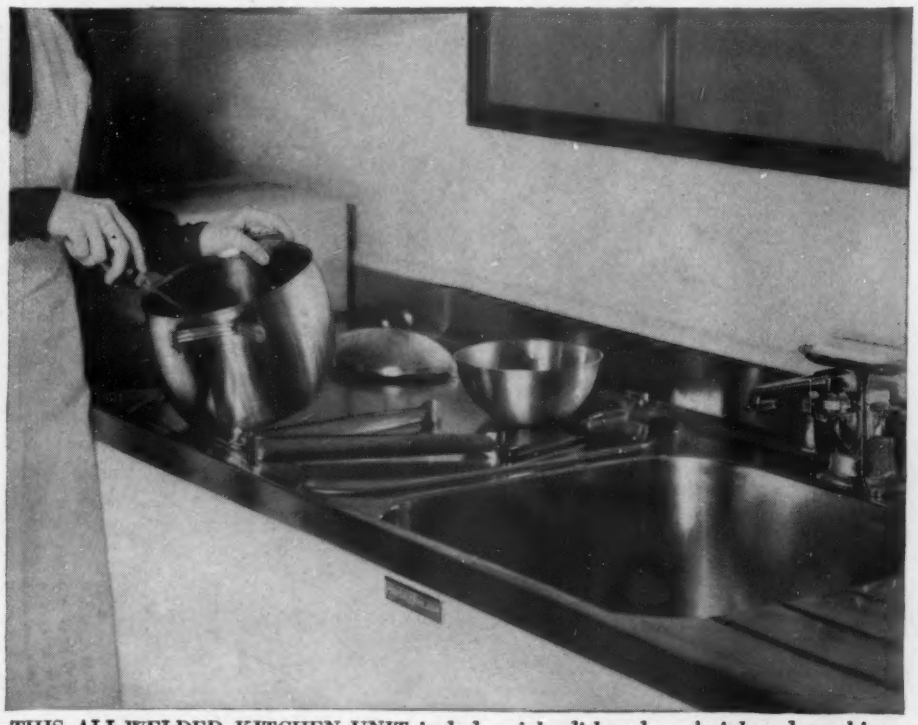
Galvanic attack, which occurs with other types of assembly, ceases to be a factor in welded equipment. In a welded assembly, the same or similar metals are fused together. Perfect electrical contact prevents the damage due to galvanic action. Abrasion by steam, water, or solids is prevented by welding on hard alloys at constrictions and bends.

Welding Stops Corrosion Losses

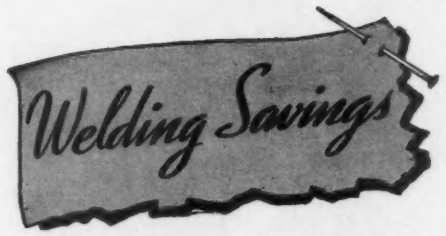
Abrasion, chemical attack, electrolysis, are defeated on a thousand fronts by welding. New equipment, designed to resist corrosive conditions and fabricated by welding to assure satisfactory performance, is achieving enviable records in service. Equipment which would otherwise be scrapped is renovated and protected against further deterioration. Many corrosion problems, localized in extent, are conquered through the application of resistant materials to the affected parts by welding.

As a result of the successful application of welding to check corrosion losses, industry is saving money. Repair and replacement bills are cut. New machinery and supplies have a longer life, and thus amortization charges are lowered. Less valuable production time is lost through shutdown and accident.

A few of the many ways by which welding checkmates corrosion, selected from actual case histories, appear in the column at the right. These and many other similar welding applications may be utilized in your future business.



THIS ALL-WELDED KITCHEN UNIT includes sink, dishwasher, drainboard, working space, and closets. It is made of stainless steel, welded into a jointless unit which is strong, easy to clean, and resistant to corrosion. Many of the utensils also are of stainless steel.



In the textile industry, stainless steel is used for dye-vats, tanks, buckets, dippers, and many other purposes. The equipment, welded throughout, resists chemical action, is smooth inside and therefore easily cleaned, and is strong and durable.

* * *

Wear by sandy water had pitted the surfaces of two 42-inch diameter balance needle valves so seriously that the valves would no longer operate efficiently. Twenty-two hours of welding saved these expensive semi-steel castings, which otherwise would have been scrapped.

* * *

In redesigning several 700-gallon tanks for food storage, it was necessary to eliminate an unsanitary and corrosion-ridden condition. The tanks were redesigned to be made from stainless steel with welded joints. The inside and outside are now permanently free from undesirable laps where germs might lodge or corrosion might start.

* * *

Sea water had seriously corroded the impellers of cargo pumps on an oil tanker. Five hours of welding repaired this damage at a fraction of the cost of new parts. Resistant metal used for the repair will prevent recurrence of trouble.

* * *

Welded piping in the floor of a skating rink successfully resists severe corrosion in addition to mechanical stress. No mechanical joint could withstand this service. The piping carries alternately refrigerating brine for freezing the skating surface and steam for melting it.

* * *

Milk storage tanks for a chocolate manufacturer were welded to prevent corrosion and unsanitary conditions. These tanks were fabricated entirely of stainless steel. They were welded to prevent corrosion at the seams as well as off-taste in the milk. The smooth, flush, inside surface left no pockets for chemical and bacterial action to produce spoilage.

* * *

A container for caustic soda solutions, made of Monel metal to resist corrosion, had a cast iron plug in the base. Corrosion troubles were imminent. By welding this and all other joints, corrosion was successfully prevented.

* * *

Tomorrow's engineers will be expected to know how to take advantage of this modern metalworking process. Many valuable booklets describing the oxy-acetylene process are available without obligation. For further information write any Linde office.

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OUR AUTHORS

FRANK BALDWIN JEWETT, writer of the article *The Coaxial Cable*, received his A.B. degree in 1898 from the Throop Polytechnic Institute, now California Institute of Technology. After obtaining his Ph.D. degree from the University of Chicago in 1902, he served for two years as instructor in physics and electrical engineering at Massachusetts Institute of Technology. Becoming transmission engineer of the American Telephone and Telegraph Company in 1904, he later advanced, in 1912, to Assistant Chief, and, in 1916, to Chief Engineer of the Western Electric Company. During the War he served as Lieutenant Colonel in the United States Army, and was advisory member of the Special Submarine Board of the Navy. He has been vice-president of both Western Electric Company and the American Telephone and Telegraph Company; in 1925 he became President of Bell Telephone Laboratories, Incorporated. Since then, Dr. Jewett has been awarded the honorary degrees of Doctor of Science, Doctor of Engineering, and Doctor of Laws. He is a member of numerous scientific and engineering societies, and is the recipient of many distinguished awards.

JOHN H. SCARFF, who wrote *Historic American Buildings*, was graduated from Technology in 1910 with the B.S. degree in Architecture. In 1911 he received an M.S. degree, and a year later was awarded the Travelling Fellowship in Architecture. He spent considerable time travelling about Europe, before serving in the United States Army as first Lieutenant during the War. At the close of the War, he went to Baltimore, where he restored some noteworthy buildings of both the Colonial and Federal periods. For a number of years, he was a member for Maryland of the standing committee of the American Institute of Architects on the preservation of historic buildings, and, as such, became District Officer for Maryland on the Historic American Buildings Survey.

DR. HARLAN T. STETSON, who wrote the article, *The New Universe*, has recently been appointed a research associate on cosmic terrestrial relationships at the Institute. He is a graduate of Brown University, Dartmouth College, and the University of Chicago. His early experiments resulted in the development of the first photoelectric photometer for determining the stellar magnitudes from photographic plates. His graduate work leading to the degree of Doctor of Philosophy was carried on at the University of Chicago. Dr. Stetson is a fellow of the American Academy of Arts and Sciences, the Royal Astronomical Society, the American Association for the Advancement of Science, and many other scientific societies. He is particularly interested in the earth's crust, an investigation which involves studies of small variations in latitude and longitude. Dr. Stetson wrote the article, *Evolution of Astronomy*; was published last month THE TECH ENGINEERING NEWS.

FRANK B. KEMP, author of *World's Fair*, came to Technology from Brooklyn, New York, as a member of the class of 1938, and entered the course in illuminating engineering. Because of his interests in journalism and photography, he was attracted to the staff of THE TECH ENGINEERING NEWS, and became Editor-in-Chief before leaving the Institute. He was also a Freshman Crew Manager, and a member of Gridiron and Scroll.

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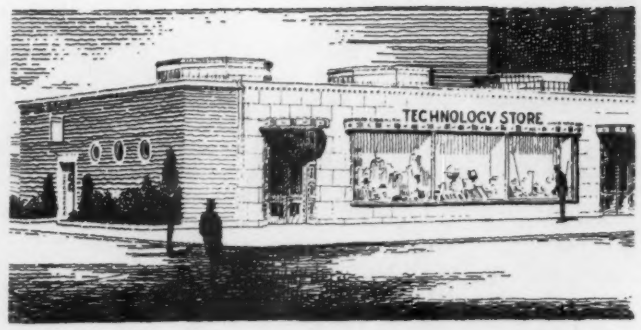

THE *New* TECHNOLOGY STORE

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CORRESPONDENCE FROM AN ALUMNUS WILL HAVE THE MANAGER'S PERSONAL ATTENTION

THE TECH ENGINEERING NEWS

APRIL, 1937
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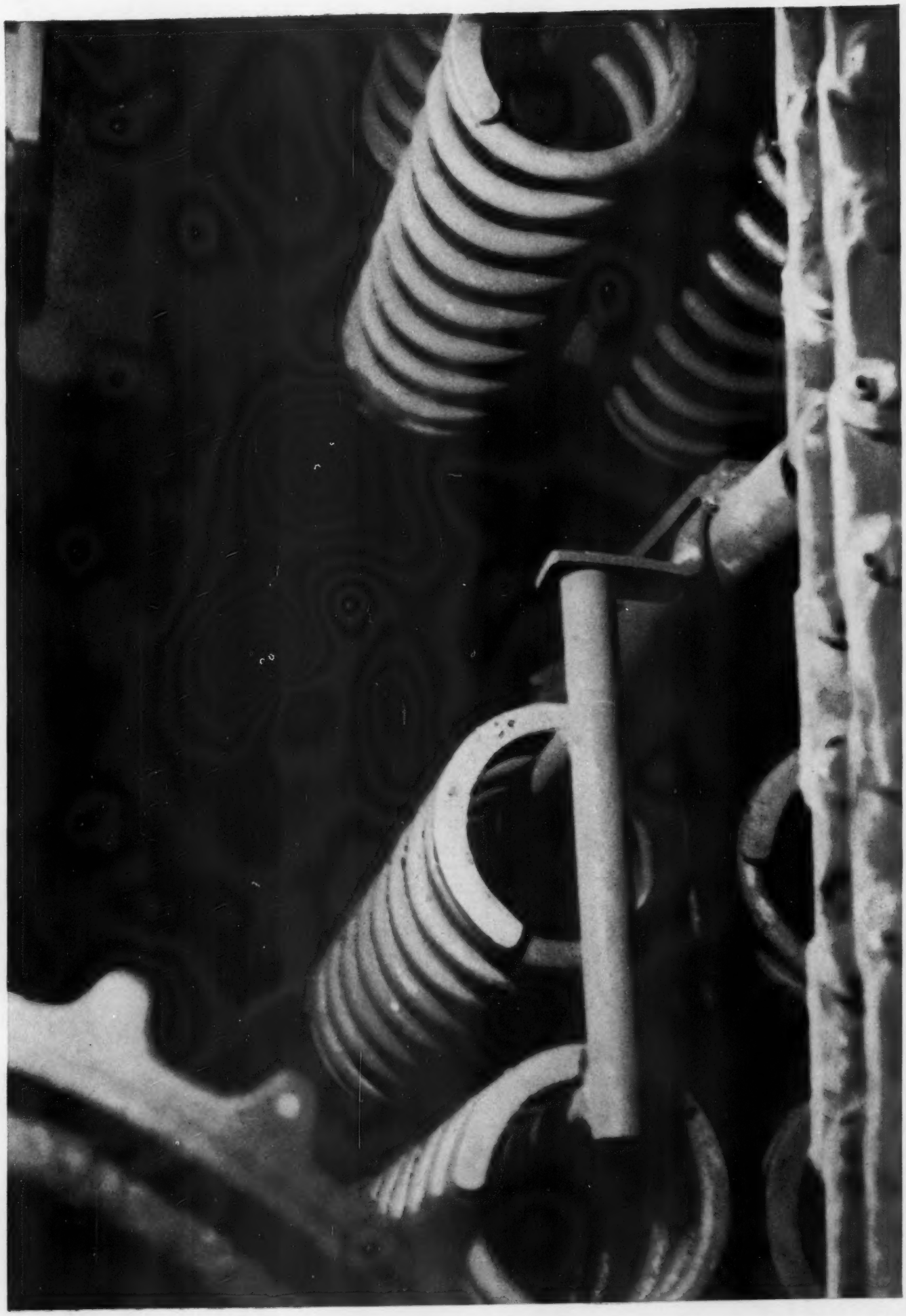


ELASTIC COILS

The Coaxial Cable

Its Successful Test-Installation Is a Step Toward Television

FRANK B. JEWETT

ON November 30th last, a variety of test conversations were transmitted over what we believe will be an important communication system of the future. From my office at 195 Broadway, New York, I talked with Commissioner Walker of the Federal Communications Commission, who was in another office building in this city, and also with Chairman Prall who was located in Washington. En route our voices made the round trip twenty times between Philadelphia and New York, using forty different frequency bands of the new coaxial cable system.

assigned to all the broadcasting stations. This range can be split up into "bands," each a separate talking channel. Ultimately 240 of these channels would enter one coaxial "pipe" at New York, bound for Philadelphia, and the same number of return channels would enter the other "pipe" at Philadelphia, giving 240 "two-way" circuits for talking. At present only 36 channels are equipped in each direction.

This demonstration marked a mile-post in a course of investigation and development into which we entered as far back as 1920, when preliminary consideration was given to

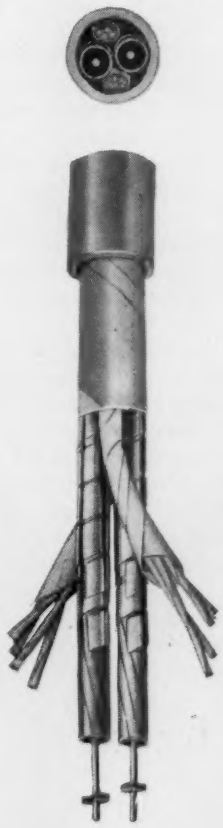
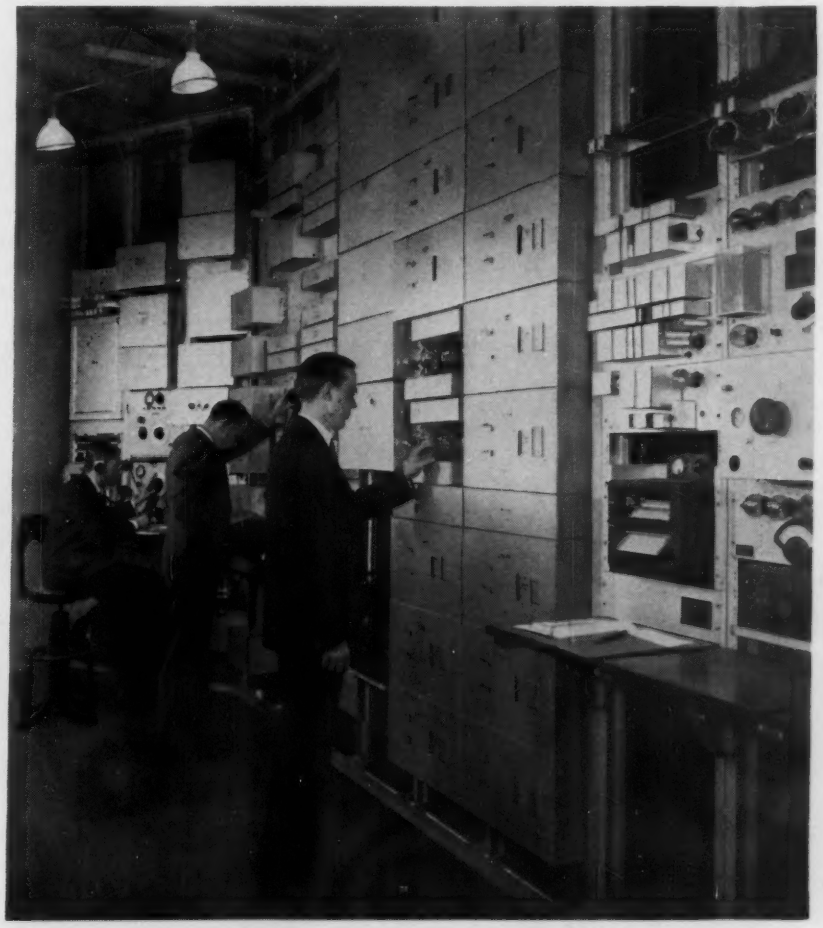


Fig. 1 Structure of the New York-Philadelphia coaxial cable.



—*Courtesy Bell System Technical Journal.*

New York terminal of the coaxial system at Long Lines headquarters.

This new cable, named from its form of construction, contains instead of the usual bundle of paper-insulated wires a pair of copper tubes. Each is about the size of an ordinary lead pencil while within it and about the same size as the lead in the pencil, is a wire held centrally by thin discs of hard rubber, spaced along the wire. As many messages can pass through this pair of tiny structures as now go through an ordinary toll cable the size of a man's arm. A coaxial cable can transmit a very wide range of frequencies — as wide in fact as the band the possibility of using a single line structure of the coaxial type for transmitting a frequency band extending up to something like a million cycles. It was recognized that to accomplish this result it would be necessary to provide, on an economical basis, not only a transmission medium capable of handling such a wide frequency band, but intermediate repeaters capable of amplifying the band, preferably without splitting it up, and terminal apparatus capable of subdividing the band into individual telephone channels without excessive wastage of frequency space. It was realized later, moreover, that a band of the order of at least a million cycles in width

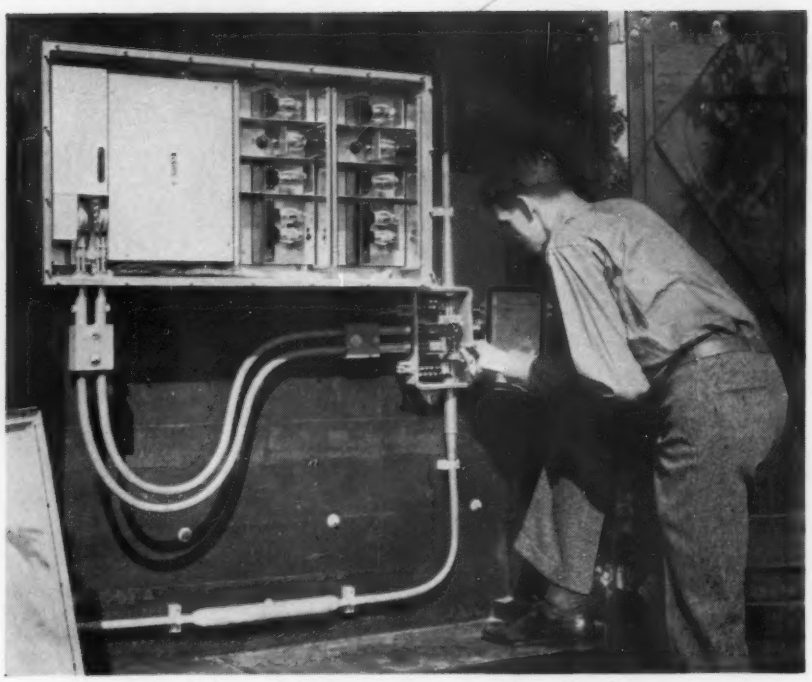


Fig. 2 For convenience, this manhole-type repeater has been installed above ground.

would be required for the rendering of television of satisfactory definition.

The coaxial circuit is by no means new, it is, in fact, a classical form of circuit. Since the time of Lord Rayleigh in the middle of the last century, the transmission properties of coaxial circuits have interested mathematicians and physicists, probably because the circular symmetry of such circuits led to exact mathematical solutions for ideal conductors.

One of the first studies in connection with this development was to determine experimentally how nearly a physiacl coaxial circuit could be made to approach the theoretical performance. For this purpose a rather large coaxial line was selected, and about two miles of it installed. This line consisted of a copper tube about two and one-half inches outside diameter, within which was mounted a smaller tube which in turn contained a small copper wire. Two coaxial circuits were thus made available. Transmission measurements of various kinds were made, which showed that the performance of the line could be predicted theoretically with remarkable accuracy.

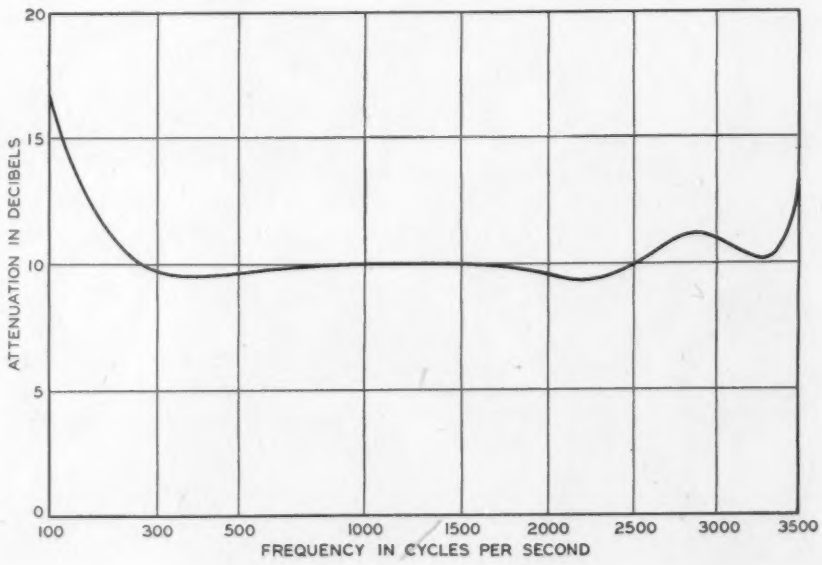
Because of the problems of installation, the most desirable form of conductor was something that could be rolled up on drums, hung on poles, and handled after the fashion of telephone cables. A wide variety of hand-made samples was tested in a search for a suitable structure.

The attenuation characteristics of coaxial conductors as compared to those of open-wire lines and cables are very favorable. At frequencies of the order of a million cycles, the attenuation of the 0.3-inch coaxial lines is such that repeaters are required at intervals of perhaps ten miles. Such frequent use of repeaters would be impracticable were it not for the fact that the repeaters are relatively inexpensive. A repeater station consists of a box hung on a pole or placed in a manhole in much the same manner as loading pots are installed. This means, of course, that the repeater must be fully automatic, requiring attention only at infrequent intervals. Power required to operate it is transmitted at sixty cycles over the coaxial line itself. A single repeater amplifies the entire frequency band.

Figure 1 shows a photograph of the particular cable used in this installation. It contains 2 coaxial units, each having a 0.265-inch inside diameter, together with 4 pairs of 19-gauge paper-insulated wires, the whole enclosed in a lead sheath having a ⅞-inch outside diameter. The central conductor of the coaxial units is a 13-gauge copper wire insulated with hard-rubber discs at intervals of ¾ inch. The outer conductor is made up of 9 overlapping copper tapes which form a tube 0.02 inch thick; this is held together with a double wrapping of iron tape.

The transmission losses of this coaxial conductor range from 1.3 decibels per mile at 50,000 cycles to somewhat over 6 decibels at 1,000,000 cycles. This attenuation is about 4 per cent higher than is calculated for a solid copper tube of the same dimensions and material. Another matter of importance is the shielding obtained from one conductor to the other or to outside interference. Inasmuch as the most severe requirement is that of crosstalk from one coaxial unit to another, this has been used as a criterion of design. While crosstalk varies with frequency, and also with the point in the circuit at which it is measured, it can be considered as roughly 130 decibels below the energy-level of the disturbing circuit.

As will be seen from the general schematic diagram, the system is designed for 240 two-way circuits. Transmission in each direction is over a separate coaxial unit, of which there are two in the cable. With allowance for spacing between adjacent channels, each channel occupies a frequency-range 4000 cycles wide, or a total of 960,000 cycles. The lowest channel is 60,000 to 64,000 and the highest 1,016,000 to 1,020,000 cycles. For the initial tests, the New York and Philadelphia terminals of the cable have been equipped to handle 36 two-way telephone conversations. The scheme employed involves two steps of modulation, the first of which is used to set up a 12-channel group in the frequency range from 60 to 108 kilocycles. Three such groups have been pro-



Schematic diagram of a coaxial million-cycle system showing frequencies assigned to the different channels.

Fig. 3

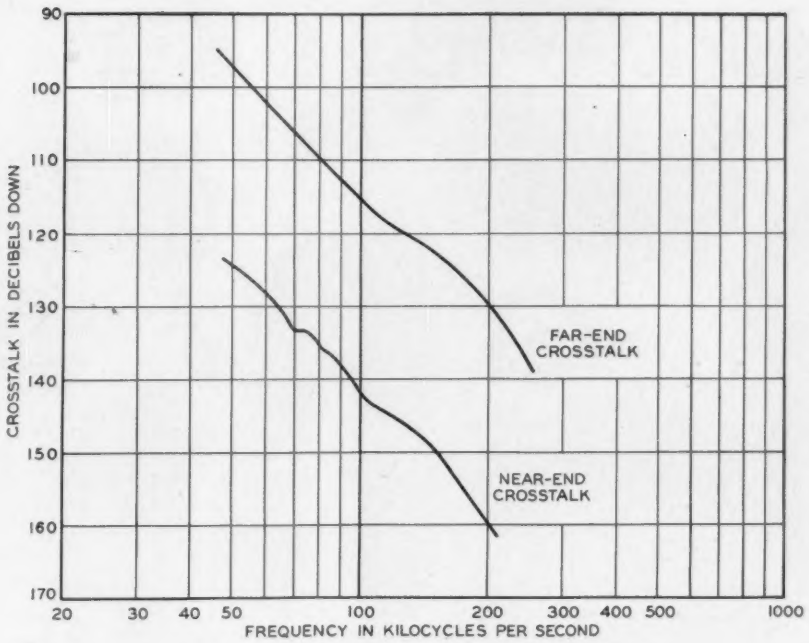


Fig. 4 Cross talk between the two coaxial conductors in the new cable.

vided in this installation. In order to transmit at the higher frequencies, a second step of modulation is used in which an entire 12-channel group is moved to the desired frequency ocation by a "group" modulator. Six such group modulators have been provided at various frequencies throughout the range, including both the top and bottom. Patching facilities have been provided so that any 12-channel group may be transmitted over any one of the high frequency paths. Relatively high speech quality has been obtained, due largely to the use of crystal filters, even though the channels are spaced throughout the frequency range at 4,000-cycle intervals.

The amplifiers used in this system were designed for about a 10-mile spacing and a frequency range of 60 to 1,024 kilocycles. A total of ten complete two-way repeaters has been provided, including those at the terminals. In the New York-to-Philadelphia cable two of the intermediate repeaters are at existing repeater stations along the route, the other six being at unattended locations along the line. Four of these are in existing manholes, while the other two were placed above ground for a test of such operation. Figure 5 shows a manhole repeater with the cover removed for routine replacement of vacuum tubes. Figure 2 shows one of the installations above ground.

Three stages of pentodes are used with negative feed-back around the last two stages. Attenuation changes due to temperature of the line are compensated automatically by a pilot channel device which has been installed at every second or third repeater. The regulating mechanism uses four small tubes and is added to the normal repeater when desired. The amplifiers shown in Figure 5 are self-regulating.

In the demonstration to which I referred, the total coaxial circuit length was 3,800 miles. This increased length for preliminary testing was gained by looping the transmission path back and forth over the same cable. One test installation over which conversations were successfully carried out consisted of five voice-frequency links in tandem, each link being 760 miles long. This layout included, in each direction, seventy stages of modulation and the equivalent of 400 line amplifiers, the transmission passing twenty times through each one of the twenty one-way line amplifiers constituting the ten two-way repeaters.

This demonstrated that the complete assemblage of parts, including filters which divide the frequency range into the required bands, modulators which produce the necessary frequency transformations, and amplifiers which counteract the line attenuation, introduced very little distortion. The systems are not, however, ready for design and production for general use. Many problems require further consideration. The final systems must have such refinement that they are suitable for trans-continental distances; the tremendous amplifications needed for such distances must have very precisely designed regulation systems, particularly where aerial construction is involved; noise and crosstalk must not accumulate over the long distances; the repeaters must have such stability and reliability that continuity of service will be assured with hundreds of repeaters operating in series.

We are literally using this cable for radio transmission, but we are transmitting through what might be called a segregated slice of the ether. In this case, however, all the ether is in the little pipes of the cable, and of course there is no static or fading.

This is not a television circuit as we are demonstrating it, but it is a necessary step toward television. We think we know how to use it for television, but that is still around the corner; all we can say at this time is that the cable gives promise of creating a possible network for interconnecting television transmitters in the future.

Fig. 5 A telephone repeater installed in a manhole.

The New York World's Fair

Landscaping the Site for a Great Public Exposition

FRANK B. KEMP

AN extraordinary thoroughness, commensurate with the vision itself, marks every advance of the New York World's Fair of 1939.

This thoroughness is apparent in the workrooms and offices of the Fair Corporation on five floors of the Empire State building, Manhattan, where under the direction of Grover Whalen this exposition is being created. It is easily perceived, too, on an excursion about the 1216½-acre site of reclaimed land along the Flushing river and bay in the Borough of Queens.

Thoroughness at all times will no doubt bring realization of plans for an exposition that, at a total estimated cost of $125,000,000, will attract the world and set up new standards.

The site already stands *fait accompli* to the world.

Last June, there at the mouth of the Flushing was an ash heap in a salt marsh. Today, an imposing expanse of new grading and lagoons is receiving the first structures of the 1939 Fair.

Preparation of the site has been completed ahead of contract schedule. One of the largest movements of earth undertaken in the East, this accomplishment, with its problems solved, chalks up another feat in the history of American engineering. Even the matter of providing top soil for the resultant acreage has involved long study and is producing a new industry.

Much that has been done for permanency at the site, and much more still to be done, could occur only through close cooperation between the City of New York and the Fair Corporation. Thus, the Department of Parks prepares the Flushing Meadow for lease to the Fair. When the gates to the exposition close, the area is returned to the City for rehabilitation as a permanent park, and the first two million dollars accruing in book profits from the Fair are to be used in the park's development. The City's plans for the park and the Corporation's designs for the Fair have been neatly arranged to avoid duplication of effort and to promote advantage for both parties in the transaction.

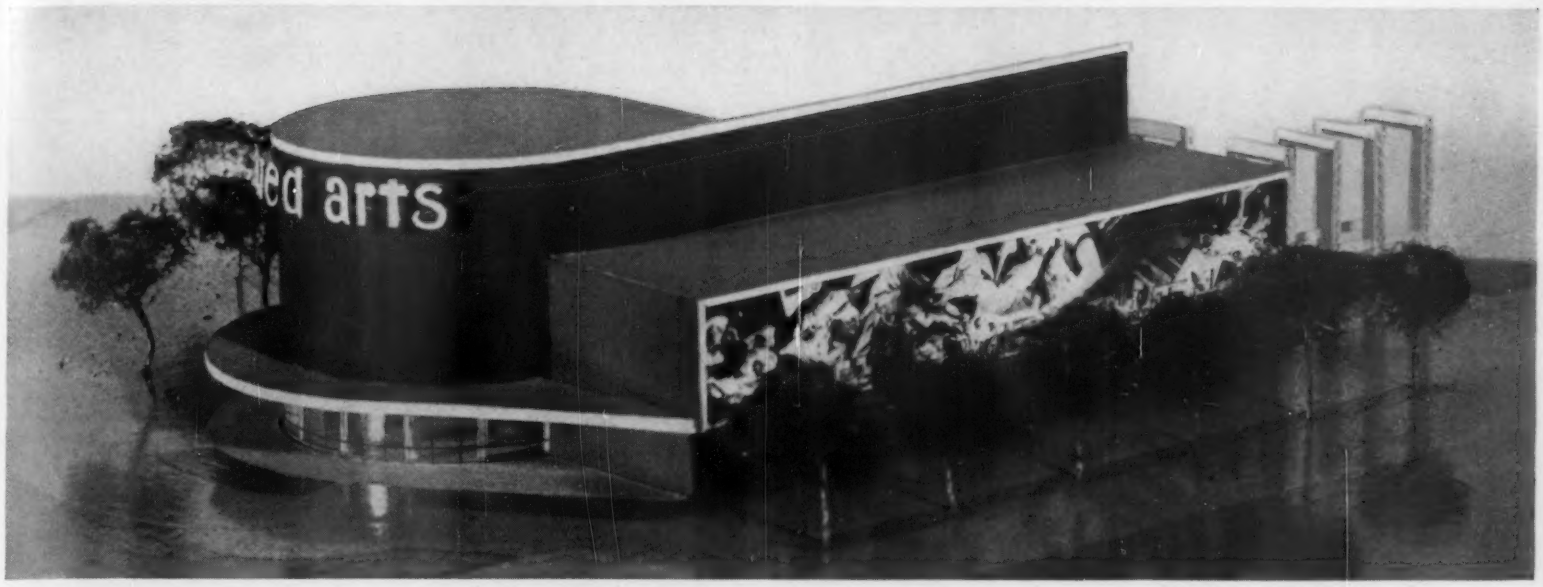
Through thoroughness of planning, for example, the Fair will be virtually embowered in trees up to twenty inches in trunk diameter; and the Park will find these sturdy specimens properly set along its pathways.

The site chosen for the Fair was one of the largest undeveloped tracts in New York City. The Brooklyn Ash Removal Company, however, had for thirty-five years been depositing ashes and rubbish in an unsightly heap in a corner of the wide expanse of tide-water swamp traversed by the meandering Flushing river. The irregular-shaped area, according to contract documents, extends for 18,000 feet southward from Flushing bay and varies in width from 500 feet to 6,000 feet. It is crossed by the Flushing subway line (here elevated), the Long Island Railroad, by four existing highways (all being reconstructed), and is tapped by numerous other roads and the proposed extension of the Independent subway system. An extension of the Grand Central Parkway leading from the new Triborough Bridge, cuts through the western and southern parts of the tract, and connects with other parkways at elaborate separated intersections.

Fortunately, there were ashes for dry fill and meadow-mat for top soil. It is doubtful whether this site would have been feasible economically without these two blessings. Hydraulic filling from the bay was undesirable, according to engineering studies, because a wet fill over the swamp mat made for instability. Dry fill in quantities is scarce in New York, and any other source of fill material would have raised the cost of ground preparation to prohibitive limits. Top soil from

—Illustrations courtesy N. Y. World's Fair.

Designers and engineers at work on fair plans.



The 1937 World's Fair has inspired new treatments for exhibit buildings.

commercial sources would likewise have been unfeasible.

The entire grading plan of the site, therefore, was based on the amount of material at hand in the ash heap. After much planning, a rolling topography was laid over the full site to balance exactly the cut and the fill. The size of two lagoons figured in the calculations, as did a new channel for the river, although meadow mat taken from the lake and stream areas for top soil manufacture did not enter into original estimates of grading.

The task was more than ordinary earth-moving operation; it required the highest degree of construction planning and management.

The problem: 6,200,000 cubic yards of dry material had to be dug out of an uneven pile, hauled an average of 4,000 feet, and spread over a swamp without producing settlement or mud waves; and 800,000 cubic yards of meadow mat had to be dredged by dragline or clamshell from the marsh and stored for future use as top surfacing—and all to be done in the maximum of 42 weeks. There was plenty of chances to go wrong. A false move might prove disastrous to a fast schedule. Contractors planned long and carefully.

For the dry excavation the successful bidders chose 1½-yard gas shovels equipped with 2¾-yard buckets, a combination possible because of the light weight material to be handled. Gas draglines with 1½-yard buckets were selected for wet work, and gas tractor bulldozers for spreading the fill at the dumps. Trucks and truck-trailer units did the hauling.

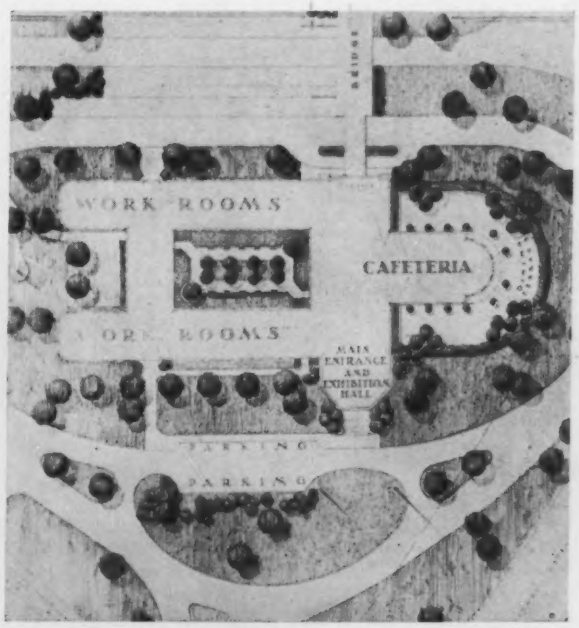
To maintain the schedule, the job was equipped with eight 2¾-yard shovels, five 1½-yard draglines, twenty 13-yard bottom-dump trailer units, seventy-six dump trucks of seven- to eight-yard capacity, fourteen bulldozers, and three truck cranes.

The ash heap was benched in 10-foot cuts. Preparations for hauling and depositing the fill, however, were more elaborate. Substantial temporary bridges and overpasses were installed where main truck routes from burrow pits to central fill areas crossed streams and highways. A bituminous macadam road was built along the edge of the swamp as a main feeder route. In unfilled areas trucks serving the dragline areas operated over roadways of 6 by 10-inch bolted timbers. The draglines themselves operated on five-foot mats made up of 14 by 14-inch bolted timbers 36 feet long. A temporary tide gate was installed to maintain the river waters at constant level. (Permanent tide control gates will practically eliminate the tidal stream and provide that the lagoons be sweet water.)

With such equipment and preparations the contractors made phenomenal progress. Work was carried on in three 7½-hour shifts each day, five days and nights each week. Daily excavations ran from 40,000 to 50,000 cubic yards. Adverse weather affected progress but little. A flood-lighting system, probably the greatest ever set up for a construction project, enabled the night forces to keep up with those at work during the day. The electric equipment, set up after competitive manufacturers had tested various types of installation, consisted of 12 steel-pipe towers, each 80 feet high, set up at points covering the cut and fill areas, and each carrying sixteen to 49 light units fitted with 1,500-watt clear lamps. This system furnished general illumination only.

The contract, awarded last June 15, called for completion by April 1. By the first day of March the site preparation had been virtually completed. Where a few months ago an un-

(*Continued on page 73*)



The proposed landscape treatment for the Administration Building.

The New Universe

Man More Fully Realizes the Extent of His World

HARLAN T. STETSON

IT was in the year 1859, the very year in which Darwin published his *Origin of the Species* which revolutionized biological thought, that the spectroscope was fairly introduced into astronomy. Newton in his optical researches had passed sunlight through a triangular glass prism and had broken it up into all the colors of the spectrum, but because he had failed to interpose a narrow slit in the light beam, Newton did not discover in the spectrum the significant "lines" which gave birth to the new science of astrophysics. As every laboratory worker knows, a fine slit interposed between the sun and the optical system of a spectroscope will produce a spectrum crossed with faint dark lines, each line occupying a definite position in the frequency scale of the spectrum that is characteristic of the state of ionization of the atoms of chemical elements in the atmosphere of the sun. When light from the interior of the sun or other star passes through an atmosphere — of hydrogen gas, for example — this gaseous envelope will subtract from the entire spectrum the particular frequencies that incandescent hydrogen would produce. The characteristic dark lines, or vacancies, thus appearing in the resulting spectrum proclaim the presence of a hydrogen envelope. The discovery of the laws of spectrum analysis underlying this phenomenon may be attributed to Kirchoff who announced them in the year 1859.

It was Sir William Huggins who first turned the spectroscope towards a little nebula in the constellation of Draco, and saw there, not the familiar absorption spectrum so characteristic of stars, but an emission spectra consisting of isolated bright lines that betrayed the existence of incandescent gas in the faint nebula. The Orion nebula betrayed itself likewise through the existence of isolated bright lines. The nebula of Andromeda reveals, on the other hand, a continuous spectrum crossed by dark lines like that of the stars. Thus Huggins by the application of the spectroscope to the telescope was able to answer Herschel's question. Some nebulae are aggregations of stars, whereas others are but diffuse clouds of luminous gas. The classification of the nebulae began.

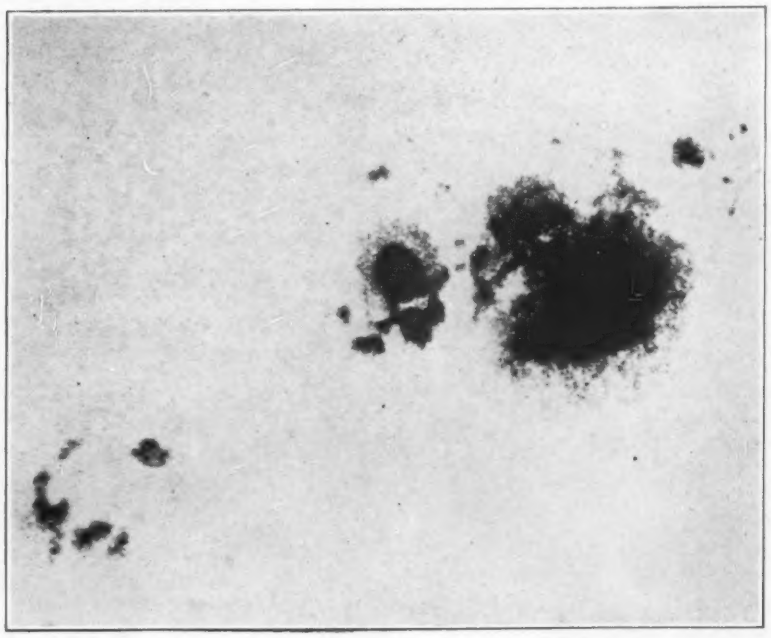
The application of the spectroscope to the analysis of starlight revealed myriad patterns of spectra, and made possible the beginnings of the vast classification of stars into an evolutionary sequence. Thus, as a result of the introduction of the spectroscope into astronomy about 1859, a process of inorganic evolution was detected in the same year that the publication of the *Origin of the Species* proposed a theory of evolution in the biological or organic world.

By the close of the nineteenth century and the beginning of the twentieth, the new astronomy, or astrophysics, was attaining a healthy growth. The establishment of new observatories in America, equipped in anticipation of the emphasis which would be placed upon the spectroscope in the new era of astronomy, gave the United States a fair lead in this field.

The Yerkes Observatory of the University of Chicago, founded and first directed by Dr. George Ellery Hale on the shores of Lake Geneva in Wisconsin, startled the astronomical world with its new and powerful telescopic and spectroscopic equipment. A refracting telescope with a lens 40 inches in diameter, the largest lens that has thus far been attempted, equipped with solar and stellar spectrographs, began, in earnest, a systematic analysis of sunlight and starlight. Dr. Hale's newly invented spectroheliograph made possible the photography of the sun in the light of a single element in the solar atmosphere. Thus it became possible to take photographs of the sun in the light of calcium or hydrogen, and to find as a result that vast clouds of calium and hydrogen gases known as floculi flitted over the sun's surface from pole to pole, and congregated in vortices about the disturbed centers where sunspots had been seen. A temperature-controlled spectrograph, especially designed for photographing the spectra of the stars, made possible an extensive study of the motions of the stars toward and away from the earth.

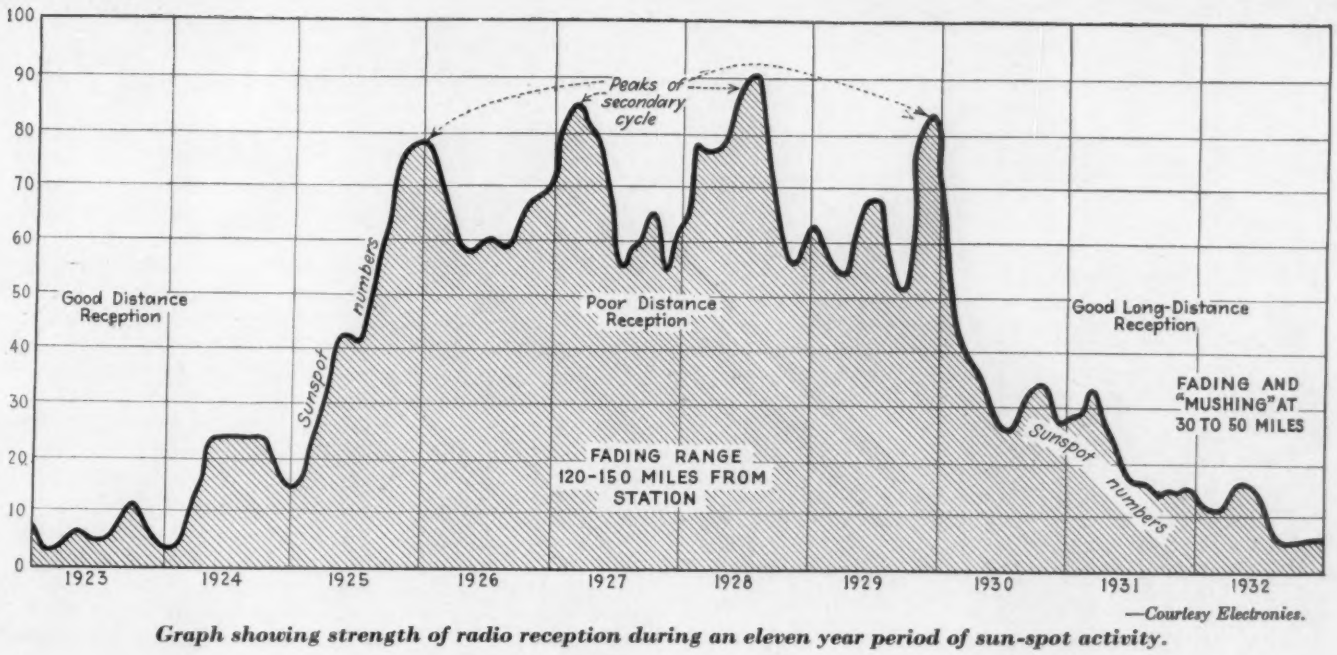
Just as the pitch of a locomotive whistle rises as the train approaches an observer and falls as it recedes, so the pitch, or frequency, in the particular note struck by light waves from hydrogen gas, or from helium, or from any other element, is slightly higher than normal if the star is approaching the earth, and slightly lower than normal if the star is receding from the earth. By measuring the distorted position of the lines in the spectra of the stars, one can calculate not only the change in pitch but the very velocity at which the star is approaching or receding from the earth. This is the well known Doppler-Fizeau principle. In the days of Herschel one had to wait decades and often centuries to discover that the fixed stars were slowly changing their positions with respect to each other. But with the spectroscope, on the other hand, a single night's observations revealed stars coming toward us, and stars going away from us, and the actual speeds of their motion in the line of sight.

So successful were the new departures in solar and stellar physics established by Dr. Hale at



—*Courtesy Franklin Institute.*

Close-up of a group of sunspots.



—*Courtesy Electronics.*

Graph showing strength of radio reception during an eleven year period of sun-spot activity.

the Yerkes Observatory, that a substantial appropriation was made by the newly-created Carnegie Institution of Washington for the establishment of a new observatory at Mount Wilson, California, under Dr. Hale's direction. Here, midst vastly improved atmospheric conditions, began the building of the most extensive observatory equipment that the world has ever known, reaching its climax in the construction of the 200-inch reflecting telescope now being manufactured for Mount Palomar, California. It is significant that in the establishment of telescopic equipment on this new mountain observatory, telescopes of the reflecting type such as Herschel built were again to come to the front in astronomy. The reflector has many advantages over the lens or refracting type of telescope, particularly, when, as in modern astronomy, almost all of the work is done by photography. Furthermore, it is possible to obtain discs of glass for a reflecting surface far greater in size than could be obtained for the making of a lens through which light must be transmitted. A 200-inch lens would require an unattainable homogeneity from the glass manufacturers.

Probably the greatest contributions that have come from the large 60- and 100-inch telescopes that have been used at Mount Wilson, and the other large instruments elsewhere, are those that have furthered our ideas both as to the evolution of the stars, their distances, distribution, motions, and the construction of the universe. From the time when the Harvard Observatory first completed its orderly classification of stellar spectra in the monumental Henry Draper Catalogue, it had been seen that an evolutionary sequence in the growth and decay of stars was apparent. Working on the observational data from the large observatories, Professor Russell of Princeton was able to establish a sequence in the growth of stars from the dull red gaseous bodies to white-hot stars, then back again to dull red bodies. The bright red star Betelgeuse in the quadrilateral of Orion is a typical star near the beginning of such an evolutionary sequence. It is a giant star, a million times as large as our sun. Its reddish glow and its complex banded spectrum indicate a surface temperature of about 3,000° Kelvin. According to current evolutionary theory, such a star is destined to contract under its own gravitation, increasing its density and rising in temperature. Characteristic of its light, it will change from red to yellow and ultimately to white. The white-hot stars attain temperatures of some 20,000° Kelvin. At such high temperatures the spectra of these stars, of which the bright star Vega is typical, are relatively simple. A continuous spectrum, stretching from the red far into the blue, is crossed chiefly by the lines of hydrogen and helium. In the hotter star, the mutilated atoms have ionized helium, betraying their effect in a conspicuous series. As these white-hot denser stars contract, they radiate more energy than they create, and the temperature slowly falls. With the fall in temperature, ionization of gases in the atmosphere of these stars decreases, and the heavier elements reappear in the spectra in increasing numbers. Continually shrinking in size and cooling in temperature, the stars become dull red bodies again, but this time of dwarf-like proportions. As temperatures continue to decrease, radiation becomes insufficient to register their presence in ordinary life.

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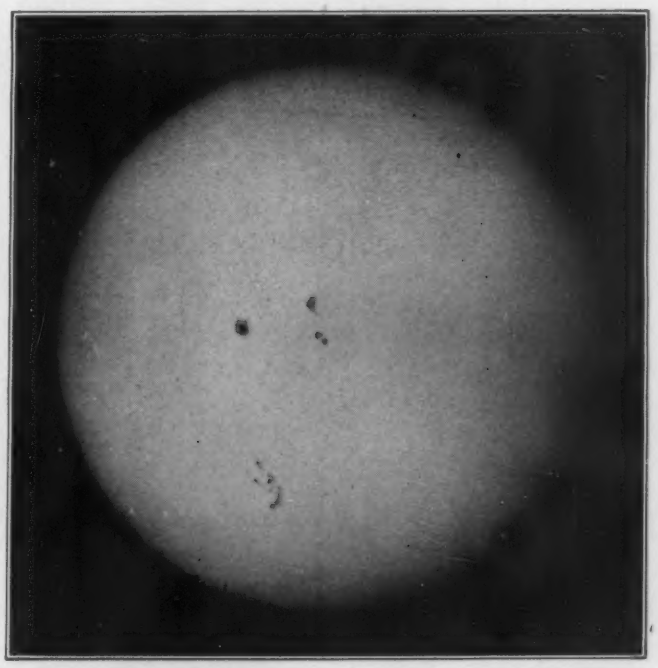


Photograph of the sun showing sun-spots.

—*Courtesy Franklin Institute.*

Historic American Buildings

A Complete Survey Will Preserve Early National Architecture

JOHN H. SCARFF

THE architectural aspect of our cities has altered beyond recognition within the memory of living men. Recording the changing order has been attempted at all times, and it is the underlying idea back of the Historic American Buildings Survey. It is not new in this country, for in 1819-1820 we find Benjamin Latrobe entering the following note in his journal:

"It would be worthwhile, and if I can find time I will try to do something of the sort, to make a series of drawings representing the city as it now is, for it would be a safe wager that in a hundred years not a vestige will remain of the buildings as they now stand, excepting perhaps, a few public buildings and a few of the houses built since the American acquisition of the country."

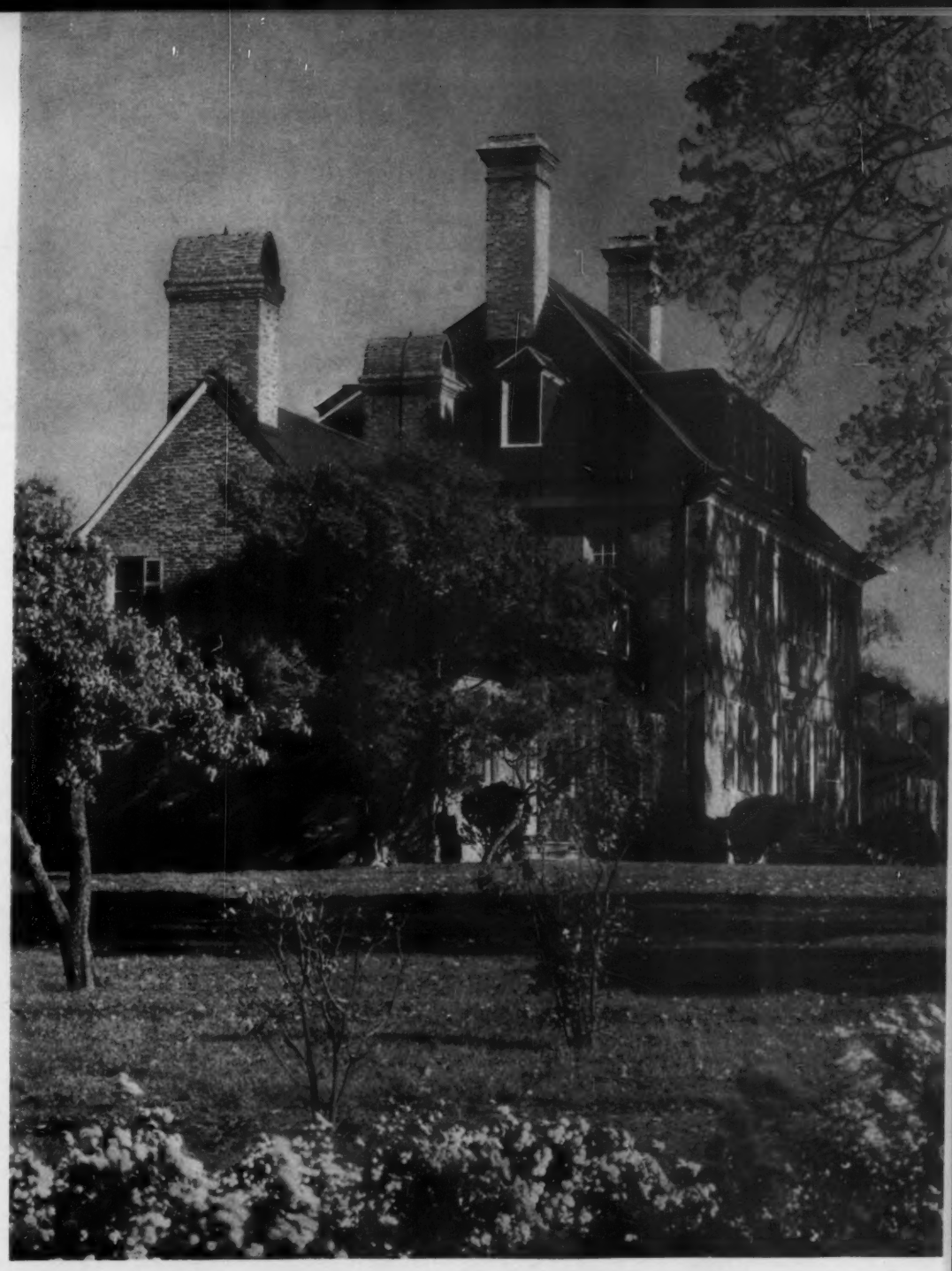
Some of the more enterprising architects have published collections of drawings and photographs of examples of early American architecture. Thus, some of the best examples of our native styles have been preserved for reference in the more than three hundred books on Early American Architecture now available.

Until recently, however, nothing had been done to establish a national archive for our native architecture. The first effective move was made by Dr. Leicester B. Holland, F. A. I. A., in his capacity as Chief of the Fine Art Division of the Library of Congress. In 1930, with the aid of the Carnegie Corporation, a new department known as the "Pictorial Archives of Early American Architecture" was established in the Library. This department embraces a collection of photographic negatives and a collection of all books on American Architecture, with a general index for their illustrations. Thousands of valuable negatives from private sources have been brought to Washington for safe keeping.

—Illustrations courtesy American Architect.

"Bremo," in Fluvanna County, Virginia, bears the characteristic stamp of Thomas Jefferson's genius in the quality of its fine brick work and the classic proportions of its porticos. Brick columns have a light stucco finish. It was built by General John Hartwell Cocke in 1819.

The depression has greatly furthered the work of collecting historical architectural data. In 1933, the executive departments of the Federal Government were asked to submit programs to the Civil Works Administration which would immediately afford work for all classes. As a planning officer of the National Park Service deeply interested in the Early American Architecture of both the East and West, Mr. Charles E. Peterson took advantage of the opportunity to submit a program for preparing architectural records. Since the relief employment of architectural draftsmen for measuring historical buildings had already been done successfully on a small scale in New York and Philadelphia, it only remained to draft a plan for organizing such work on a nation-wide scale in such a way as to obtain the financial support of the Federal Government through the Civil Works Administration. The advice of the American Institute of Architects was sought in formulating a suitable program. The Library of Congress had already made a strong beginning



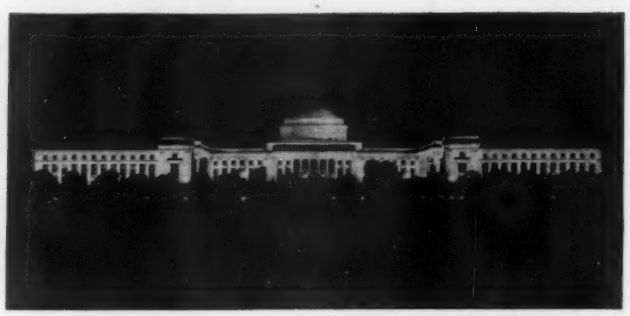
"Carter's Grove," in James City County, remains the only great house in the immediate vicinity of Williamsburg. Built by Carter Burwell, in 1751, it was designed by David Minitree, an English master mason, who also supervised its construction. It was acquired by Mr. and Mrs. Archibald McCrea in 1927 and restored under the supervision of W. Duncan Lee, Architect.

with its photographic archives, and was the ideal repository for government-owned architectural records. Fortunately, the interests of the American Institute of Architects and the Library of Congress were both ably served by Dr. Holland, who gave the project enthusiastic and effective support from the beginning.

On November 13, 1933, a memorandum proposing "the relief employment under the Civil Works Administration of a substantial number of the architectural profes-

(*Continued on page 75*)

THE TECH ENGINEERING NEWS



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EDITORIALS

AIRLINE ACCIDENTS

THE recent occurrence of several major airline accidents prompts a consideration of the engineering problems as faced by the airlines. A study of the reports issued by the Department of Commerce on the airline accidents of the past reveals that the airlines have not yet reached full maturity. This form of transportation has made phenomenal advances, but it still cries out for further research and development. The accidents of the past are not shrouded with the veil of mystery eternally credited to them by the news agencies. Instead, these accidents can be catalogued under definite engineering problems. As each problem is solved, the possibility for the future occurrence of some type of accident is erased. The re-occurrence of many types of accidents is precluded by preventative measures that have already been evolved. Many other developments, however, remain to be made before air travel is established on the desired level of reliability and safety in operation.

The needed developments in airway facilities are not to be viewed as unobtainable. The past record of science assures that we may confidently expect the answers to all questions and solutions of all problems through the natural evolution of the sciences, after a period of time.

It seems criminal, however, to allow a form of public service to labor under hazardous conditions when these conditions could be relieved by an intense program of research, development, and re-equipment of facilities.

Several scientific agencies have engaged in programs designed to facilitate air commerce and eliminate the causes of aircraft accidents. These programs have of financial necessity been on a modest scale. The government would do well to financially encourage these and other like projects. Science has asked for work to do. The engineering problems of the airlines would surely provide a serious program for science. Financially aided by the government, the scientific agencies could unquestionably evolve solutions to the operation problems faced by the airlines. Such subsidization is by no means out of order since it has always been governmental policy to encourage and foster all modes of transportation through, and in many cases beyond, their adolescent stages.

Apparently, the greatest need in commercial aviation today is a system that can be relied upon at all times to give perfect indications for navigation. With a perfect system of navigation commanding the implicit faith of operating personnel, over 50 per cent of the airline accidents of the past and expected accidents of the future would not or will not happen. The regular operating personnel of an airliner might advantageously be increased by the addition of a navigator.

Utilization of baggage space would enable his inclusion in the crew. True, 99 per cent of the time the jobs of flying, radio operation, and navigation can be competently handled by two men, but the other one per cent of the time would fully justify the addition of a navigator to the crew of the modern airliner.

Despite all the navigation aids, however, that have been and are being developed, the human element in piloting remains to a much too large degree. The trend of turning more and more of the pilot's duties over to mechanical aids, such as the "robot pilot," is definitely leading towards the desired all mechanical operation of the airliners, and such a trend must be encouraged.

A notable record may be claimed by the structure engineers in that none of the serious accidents of the past few years can be attributed to structural failure. It is truly the accessories and personnel rather than the airplane that need the most research and development.

It is not meant to convey the thought that present day air travel is more hazardous than other modes of travel. Statistics prove that you are safer traveling by air than by several other common carriers. It is rather the desired thought that until the airways are definitely established as unexcelled in reliability of operation as well as safety, the engineer and scientist have not completed their task for the airlines.

CHEMISTRY AND THE FARMER

OF late years there have been a number of forces and causes that are surely spelling the doom of many of the farmers of the nation. Three causes seem to be outstanding. First, the intensive farming methods using synthetic fertilizers and mechanization have brought about a condition whereby more crops can be grown on less land. Secondly, a number of synthetic products have sprung up as a result of chemical research, achieving uniformity unattainable by the farmer. And third, a world tendency toward self-sufficiency has cut down world trade in agricultural products. The first two causes are perhaps the most dangerous to the farmer.

For, in 1790 it is estimated that ninety per cent of the population were engaged in agricultural pursuits, whereas in 1930 twenty per cent of the population were farmers. A report of the Department of Agriculture shows that eighty-five per cent of the agricultural products that entered into trade in 1930 were produced by one-half of the farmers. Experts say that five per cent of the farmers could have produced the crops of 1930 if best-farm operations known had been utilized. Assuming that five per cent is a bit too low a figure, it still shows what may happen to a great many of our farmers. W. J. Hale, a chemist, in his book, *The Farm Chemurgic*, estimates that chemical research has made futile twenty-five per cent of the population of Europe and America in three decades. But what has the chemist done to help these people?

Doctor O. M. Willcox states in his book, *Reshaping Agriculture*, that four out of every five farmers and four out of five acres could be dispensed with, if the best-farming practices known were adopted. Granting again that Dr. Willcox's figures are too high, we still see an enormous economic problem impending.

Synthetics, developed by the chemist, have thrown millions of acres of land out of cultivation. Crops that were used for dyes and flowers that were used for perfumes now can be almost entirely dispensed with. American agriculture, says Dr. Willcox, is only 11.3 per cent efficient. Bringing this figure up to 22.6 per cent, a figure still under most European efficiencies, would be catastrophic, he states. He further holds that with an efficiency of seventy per cent of best-known standards, one that is entirely feasible, an area of forty million acres, less than the farm area of Kansas, would suffice for American agriculture. This is not a promising future for the farmer to look forward to.

Controlled agriculture, a product of the chemist, may yet raise havoc with the farmer. By such methods a fresh crop, entirely uniform and independent of the vagaries of nature, results. Crops can grow in metal trays in ovenlike cabinets. The crops furnish their own heat, and a few hours each day are needed to supply water and chemical food to the plants. Some crops can be had fresh every day. A tray of seed corn will sprout in a few days, and in ten days the corn is a foot high. This method is gaining popularity in England, Denmark, and Germany, where it is used to grow fodder crops for cattle and poultry. If such a method is ever developed on a large scale, it will spell economic ruin for millions of farmers.

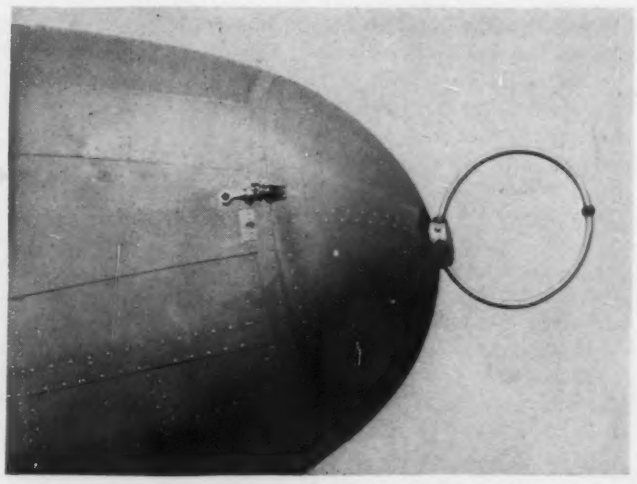
We do not advocate that the chemist lay down his test tubes and leave agricultural progress in a state of stalemate, but it is stressed that the chemist must think of the results of his researches, and provide some other means of livelihood to those farmers who are adversely affected. This is not mere idealistic prattle. A definite and threatening economic problem is impending, and the chemist must do his share to alleviate the results of his researches.

T. E. N. CUP

IN order to provide an added incentive to increase the standards of undergraduate engineering publications, *The Tech Engineering News* is offering a cup to the finest undergraduate scientific and engineering magazine of the year. This cup, which is to be known as *The Tech Engineering News Cup*, will be awarded annually and become the permanent property of the publication that wins it three consecutive times.

The award is to be made on the basis of: general appearance of the magazine; scientific and engineering merit of the articles; make-up and composition of the magazine; extent and distribution of circulation; effectiveness of illustrations and art work; editorial excellence.

Of the five judges who are to select the most outstanding publication, three are present at the Institute — J. R. Killian, editor of the *Technology Review;* F. G. Fasset, Assistant Professor of the Department of English; P. McC. Morse, Associate Professor of the Department of Physics. The other two judges are connected with firms situated in Boston — Mr. John Burchard, '23, of the Bemis Industries, a housing corporation; and Mr. Carlton Strong, of the Boston office of Rumford Press.



RESEARCH IN REVIEW

COURSE XVI — Aeronautical Engineering

A METAL airplane propeller in operation acts as a freely vibrating body, with stresses dependent on many different types of resonant vibration. In order to obviate structural failure which these resonant vibrations are likely to cause in a propeller, a practical method for the measurement of strains in rapidly moving parts is needed. A research program designed to develop such a method is now in operation under the direction of Professor A. V. de Forest.

The Institute, in conjuction with the Hamilton Standard Propeller Company, has in development a method for the continuous indication and recording of local stress, acceleration, or displacement, with phase relations between the local motions and cylinder explosions. Among the many attempts to reach this goal were tests with acoustic pick-ups used with a sound analyzer, but no solution was found. A direct optical method using small concave mirrors mounted at different points on the blades, each tracing a small circle on a screen in line with the center of the shaft, was tried; the resulting patterns were too complex for ready analysis. Much work was carried on with various electrical strain gauges or accelerometers to be attached directly to the blades, the resulting indications carried through collector rings to an amplifier and oscillograph; again, difficulties were encountered in the complicated wave forms which resulted.

Last year a new line of experiment was opened up by Mr. E. H. Hull of the General Electric Company, who had successfully used the change in resistance of a strip of conducting paint under vibratory stresses. His pick-up consists of an insulating layer of paper cemented to the metal surface, and carrying lead-in contacts of tinfoil cemented to the upper surface of the insulating paper. The paint, applied between the two contact strips, was made of very finely divided graphite either in water or alcohol suspension. The steady resistance of the strip varies in an irregular manner at zero load because of temperature, moisture, and perhaps other disturbances. To avoid this difficulty, the amplifier was built to record only the cyclic fluctuations and to be insensitive to slow changes in resistance, provided the stress variation is above 300 cycles per minute. Thus, only change in resistance with strain is recorded. The measurement of strain was found to be almost independent of frequency, and closely proportional to strain amplitude.

Research at the Institute then concentrated on the preparation of strain-sensitive strips which could be precalibrated, attached to a metal surface, and removed therefrom without disturbing the calibration, and which would be suitable under both static and dynamic conditions. Many different insulating materials, mixed with graphite or carbon were tried. Thin paper with a graphite and sulfur mixture melted in was found to be practical. Pencil leads also showed good sensitivity.

Meanwhile, Hamilton Standard found suitable characteristics in baked carbon resistor units as used in the radio industry. Plastics, such as bakelite loaded with carbon, were also investigated, and, with the assistance of the Arthur D. Little laboratories, loaded bakelite sheet was produced. These strips are sensitive to strains of 0.0002 inch, and are reasonably free from moisture and temperature changes.

In some cases the tuning for resonance is broad, extending over a couple of hundred revolutions per minute; in other cases the tuning is much sharper, and suggests resonance between a propeller period and one of the forms of motion of the crankshaft. Much more investigation is necessary to locate the exciting forces under all conditions. In the first place, the motion of the engine in space must be considered, and, in the second place, the various modes of vibration of the engine crank must be definitely known.

Suitable directional accelerometer units and torsional vibration units have been developed by Professor C. Stark Draper and Mr. Bentley of the Institute. A combination of these instruments with dynamic strain measurements of all important parts of a propeller and engine will no doubt lead to a much better understanding of the origin of propeller stresses than has before been possible.

Such methods also give promise of being beneficial to other fields for the study of rapidly moving parts.

COURSE III — Physical Metallurgy

IN a joint approach to technical problems encountered in the metal casting industries, the New England Foundrymen's Association and the American Foundrymen's Association will hold a regional conference at the Massachusetts Institute of Technology on April 9 and 10. Co-operating in the conference will be the American Society of Mechanical Engineers, the American Society of Metals, the American Welding Society, and the American Institute of Mining and Metallurgical Engineers.

The conference, the first of its kind ever to be held in New England, will bring together about 500 engineers, metallurgists and foundrymen, and will be opened on April 9th by Dr. Vannevar Bush, Vice-President of the Massachusetts Institute of Technology. The technical sessions on the first day will include a discussion on "Casting Design — Iron." Chairman of this session will be E. H. Ballard, and a paper will be given by E. M. Phillips, General Electric Company, Lynn. Colonel C. F. Jenks will be chairman of a technical session on "Casting Design — Steel," at which V. T. Malcolm, metallurgist of the Chapman Valve Company, Indian Orchard, Mass., will deliver the paper. "Casting Design — Non-Ferrous" will be the subject of another technical session at which Professor Robert S. Williams of M. I. T. will be chairman, and Harold J. Roast, Vice-President of Canadian Bronze, Ltd., Montreal, will be the speaker. At a late afternoon meeting Professor J. M. Lessells of M. I. T. will discuss "The Testing of Cast Iron."

The first day sessions will end with a dinner at Walker Memorial at which the speakers will be Dr. Karl T. Compton, President of Technology, Walter M. Saunders, Jr., President of the New England Foundrymen's Association and D. M. Avey, Secretary of the American Foundrymen's Association. R. F. Harrington of the Hunt-Spiller Manufacturing Company of Boston, will preside, and the program will include the showing of Technology's high speed motion pictures, with a talk by Merwin Horn of M. I. T.

The sessions on the second day, Saturday, April 10, will include a discussion of "Molding Sand" by W. J. Reichert, metallurgical engineer of the Singer Manufacturing Company of Elizabethport, N. J. The chairman of the session will be A. S. Wright, and "Sand Testing Technique and Demonstration" will be the subject of a paper by Earl E. Woodliff, Research Engineer of the Harry W. Dietert Company, Detroit. The technical session in the afternoon at which Charles F. Miller, of Woonsocket, Rhode Island, will preside, will take up the discussion of "Cupola Operation." The speaker will be Donald J. Reese of the Development and Research Division of the International Nickel Company of New York. Following these sessions there will be demonstrations of testing in the Institute's laboratories.

Model used in illumination research.

NOW that the reading room of the Central Library at M.I.T. has been made one of the few decently-lighted spots at the Institute, one may well consider the lighting history of the room. The original system of illumination was hopelessly inadequate from the start and was soon replaced by an arrangement designed by Professor Drisko. Thirty-two 500-watt incandescent lamps with silvered-glass reflectors threw beams of light on the inside of the hemispherical dome, whence the light was diffusely reflected to the tables below. The resulting illumination was uniform and had an initial value of 4 lumens per sq. ft. on the tables.

Gradual deterioration of the reflectors and darkening of the painted surfaces of the room, however, caused a reduction in the amount of useful light until the illumination of the tables had dropped to 1.5 lumens per sq. ft. Such a value might be satisfactory for a corridor but was certainly not suitable for a reading room. Mr. John M. Ness became interested in the problem, and in his Master's thesis (1932) he studied various ways of lighting the library. To check his involved calculations he built in the Illumination Laboratories a scale model of the reading room, and with it he made measurements of illumination with various kinds of lighting. Mr. Ness concluded that excellent results would be obtained by using an artificial skylight 24 feet in diameter of diffusing glass, above which would be placed a large number of lamps. Presumably, this arrangement would give an effect very similar to that obtained in the Pantheon, after which the M. I. T. dome was modeled and in which skylight came directly through the circular opening in the top.

Last year the subject of lighting came up again in connection with the general improvement of the library. Professor Parry Moon, '27, made a further study of the subject. It was finally decided that the most satisfactory seeing conditions would be obtained by continuing to use the scheme of Professor Drisko but with larger lamps and improved reflecting equipment. Such an arrangement is less efficient than the artificial skylight in utilizing the light from the lamps but it is much better from the standpoint of reflected glare. Accordingly, heavier wiring was installed and thirty-two 1500-watt lamps were used. The 48 K.W. of electrical power produces an illumination of approximately 15 lumens per sq. ft. on the tables, and this value can be almost doubled at any future time by merely repainting the dome walls.

HUMAN ENGINEERING

THE Massachusetts Institute of Technology and Harvard University will be joint hosts to more than 1500 members of the Society for the Promotion of Engineering Education, which will hold its 45th annual meeting in Cambridge, June 28 through July 2.

Discussions concerning both technical and non-technical aspects of the engineering curriculum, symposia on the relation between university and industry and inspection of Harvard and Technology electrical engineering laboratories will feature the program planned for these leaders of industry and education.

Those subjects believed to be of sufficient general interest will be presented to all participants, while round-table groups will consider some of the more limited aspects of these general topics as well as specialized questions of particular interest to those present.

The arrangement committee is composed of Dr. Vannevar Bush, Dean of Engineering of Technology, Chairman; Professors H. R. Mimno and A. E. Norton of Harvard University; Professors A. L. Townsend, K. C. Reynolds, C. Frank Allen, D. C. Jackson and C. E. Tucker of M. I. T.; Professors G. C. Anthony and H. P. Burden of Tufts College, and Professor Carl S. Ell, of Northeastern University.

RESEARCHES OF 1936

In its annual review of yearly progress, Science Service, the institution for the popularization of science, includes the following achievements of Technology staff members during the year, 1936.

The United States Navy in co-operation with M. I. T. developed the Draper electromagnetic apparatus for recording of engines' and airplane parts' vibrations while in flight.

Small unmanned balloons equipped with robot radio transmitting sets were used for automatic recording of upper-air weather information and cosmic-ray data in the field tests of Dr. Thomas Johnson, Bartol Research Foundation, and of a joint expedition of Harvard University and M. I. T. under the direction of Dr. K. O. Lange.

Eclipse observations by the Harvard-M. I. T. expedition showed several new coronal lines and indicated to Dr. Donald H. Menzel of Harvard a close connection between high excitation in the chromosphere and the strength of the, as yet, unsolved coronal radiation.

A new method for determining the age of rocks by their helium content was announced by Dr. William D. Urry.

A mechanical calculating machine capable of solving nine simultaneous linear algebraic equations was completed at M. I. T. Designed by Dr. John B. Wilbur, '26, the simultaneous calculator has wide uses in civil engineering, nuclear physics, genetics, and psychology.

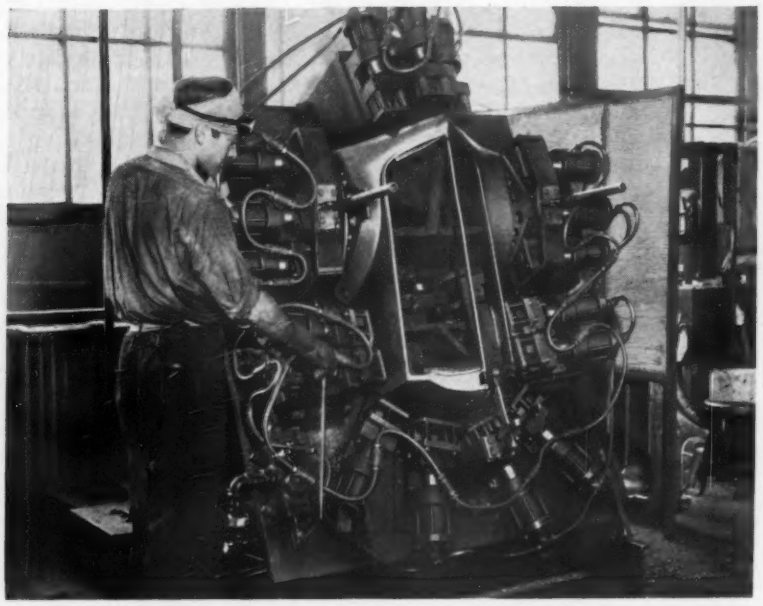
Detection of radium poisoning became more accurate through the application of a new type of screen-cathode quantum counter developed by Dr. Robley D. Evans and said to be 10 to 100 times more sensitive than older methods of detecting radium in the body.

Five wavelengths compose the portion of ultraviolet light which cure experimental rickets by irradiation, and of these the one which is most effective rarely reaches the earth in sunshine, Professor John W. M. Bunker and Dr. Robert S. Harris, '28, reported.

Experiments with radio waves only six inches long, which travel along hollow tubes, were simultaneously announced by Dr. G. C. Southworth, Bell Telephone Laboratories, and Dr. W. L. Barrow, '29, of M. I. T.

(*Continued on page 80*)

ENGINEERING DIGEST



MULTIPLE PUNCHES

CONSISTING essentially of nineteen hydraulic cylinders mounted on a steel plate, a machine, capable of punching 35 holes accurately and simultaneously, has been designed. The cylinders are used either for the clamping or punching of radiator shells. The hydraulic head of each cylinder is fitted with a spring-backed pad, which is advanced to press the shell against inside blocks bringing it to desired shape, the holes being pierced as the rams of the hydraulic cylinders complete their movements. The shell is also held by clamps. The pierced holes, necessary for many purposes, need not be punched oversized as heretofore, since simultaneous punching insures a tight-fitting radiator shell.

Machines of the same principle are used to pierce holes in fenders. Such machines are provided with ten hydraulic cylinders for punching thirteen holes, right- or left-handed machines being used as required.

—Machinery

RADIANT-TUBE HEATING

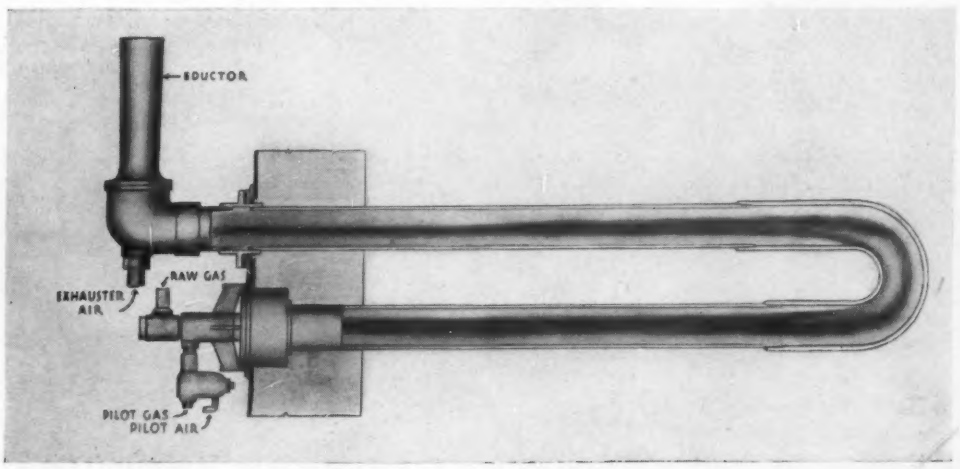
WITH the recent commercial application of the radiant-tube heating system, the demands of industry for large continuous furnaces that are capable of heat-treatment without oxidation, or with controlled oxidation have been largely met. Utilizing a principle known as diffusion combustion, the radiant-tube heating element makes possible a far higher rate of heat transfer than the convection system. It has been found that the radiation is proportional to the fourth power of the temperature difference between the work and the heat source, whereas the heat transferred in the convection system is proportional only to the first power of the temperature difference.

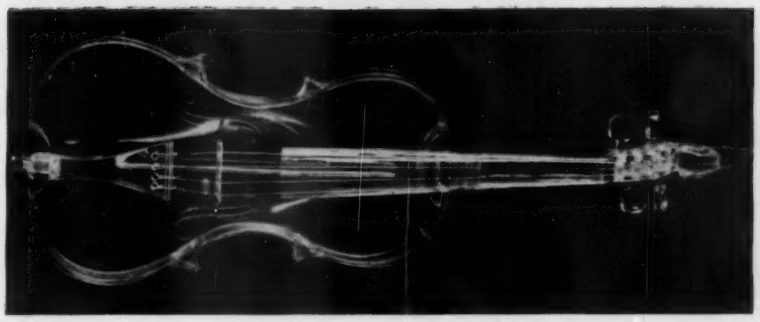
The highly satisfactory heat transfer rate arises from the application of diffusion combustion, in which the ability of two gases to intermingle is employed to secure a progressive burning throughout the combustion tube. Air and gas are introduced at one end, where combustion begins, and the tear gas strata travel parallel to each other at equal velocities. The combustion continues until, at the exit, the gases have been completely burned. In this manner, a uniform temperature is maintained and the occurrence of hot spots prevented. Consequently, if the tubes are properly arranged, there will be no hot spots in the furnace — a notable improvement over the convection method.

For ideal diffusion combustion, it is essential that there be no turbulence in the gas stream. Actually, however, the shape of the furnace, the location of the doors and conveyors, together with several other factors, make impossible the achievement of the ideal state. The accompanying diagrammatic view illustrates the nearest approach to true diffusion combustion that can be attained in industrial practice. The turbulence at the end of the tube is well defined.

The radiant-tube heating system has been readily adopted by those industries which are concerned with some type of heat treatment. Recently a large malleable iron plant in Michigan ordered constructed a heating unit which, when completed, will be the largest radiant-tube furnace in existence. The operating cycle is expected to be approximately thirty-one hours, a considerable saving over the two and one-half to three and one-half day cycle previously required. The radiant-tube furnace has found application in several other processes, particularly in spheroidizing, hardening, and annealing, where the properties of the new system are especially desirable.

—Machinery





CRYSTAL CLEAR MUSIC

CONSISTING of plexiglas, a transparent plastic, several types of musical instruments, including a violin and flute, have been made in Germany. The violin has splendid tone, but lacks volume, while the flute is said to have excellent tonal qualities, entirely suitable for concert work. Both instruments, which were machined, fitted, and cemented together, are made of shells, rods, and blocks of Plexiglas, which is manufactured in this country by The Rohm and Hass Co. of Philadelphia.

Indicative of imaginative and creative phenomena, such departures from the traditional are now particularly appropriate because of the increasing availability for experimentation of new transparent resins of greater stability. The material is of practical value since it is quite light, and can be machined and molded, thus insuring inexpensive production, and permitting use in competitive fields. Moreover, the versatility of the material permits many uses to which glass could not be subjected, yet combines a decrease in weight.

Molding probably will be the most practical method of fabrication for extensive production, but rods, tubes, sheets, and blocks, being generally available, may be combined with molded forms to complete designs.

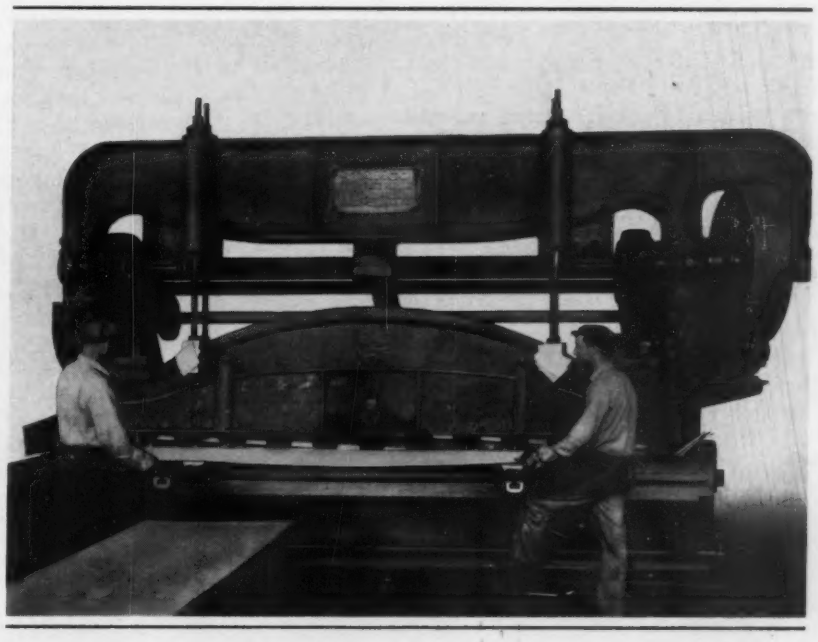
The violin and flute illustrate the opportunities of using transparent resins that do not change their color in service, while new ideas, undertaken in creative spirit, will doubtless present themselves. Packaging and decorating fields will probably welcome these materials as departures from conventional types of plastics.

—*Modern Plastics.*

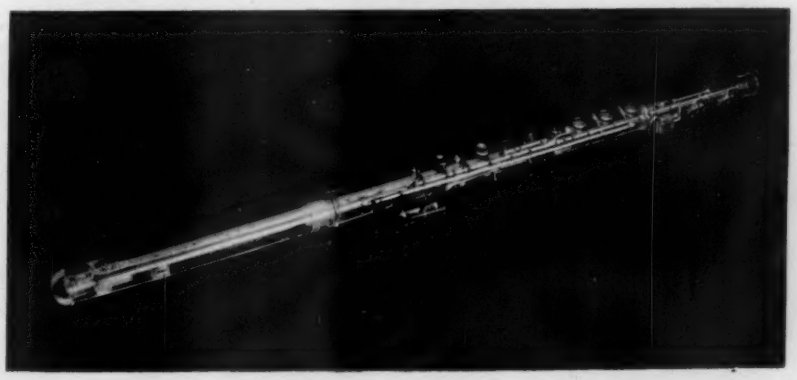
HARD-FACING METALS

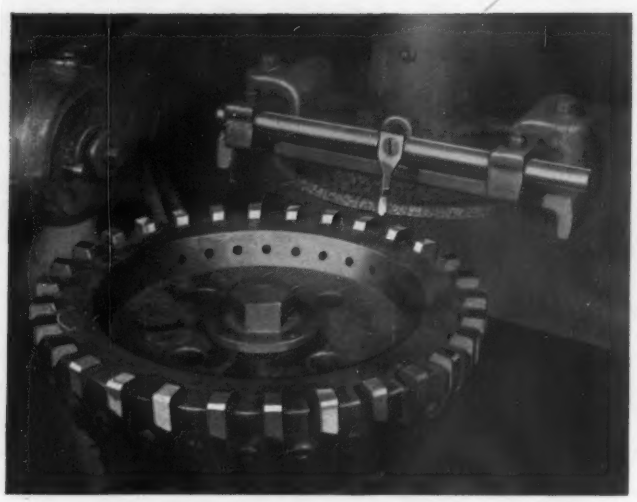
HARD-FACING is the process of welding a coating of a metal capable of resisting abrasion to metal parts subject to wear. This simple process will save, it is estimated, some tens of thousands of dollars in maintenance costs this year. These impressive economies can be traced to the greatly increased life of those metal parts protected by hard-facing, an increase averaging from 300 to 1000 per cent compared with parts not so protected. The fewer replacements and less frequent shut-downs have resulted in more efficient and less costly production. Parts formerly relegated to the scrap heap may be coated with the Haynes Stellite alloy of cobalt, chromium, and tungsten, and then returned to service at a fraction of the cost of new stock.

The Stellite welding can be applied by either the oxy-acetylene or the electric arc process. The former method reduces the dilution of the hard-facing deposit with iron from the base metal and, therefore, it is usually preferred. Since the exceptional properties of Stellite depend upon its non-ferrous composition, a dilution with iron would impair seriously its ability to resist abrasion. In practice, an excess acetylene flame is employed to secure the proper sweating of the base metal. When the base is at sweating heat, the Stellite alloy is applied to the surface, and a strong junction effected without any appreciable inter-alloying of the two metals. The hard-facing deposits vary — from 1–16 to 1–4 inch thick, a coating sufficient to protect the metal part from the most extreme abrasion.



Stellite hard-facing has found innumerable applications in the machine shop. Trips, cams, dogs, locating points in jigs and fixtures, hot trimming dies — all serve their purpose with increased efficiency. The accompanying illustration shows one important tool which is now almost invariably processed with Stellite.





The aim in applying Stellite is to flow the alloy over the surface of the base metal when the later is at a sweating heat. If this is properly done, a strong junction is secured without any appreciable inter-alloying of the two metals. The exceptional properties of Stellite depend upon its non-ferrous composition of cobalt, chromium, and tungsten. Dilution with iron would reduce its ability to resist abrasion.

—*Machinery.*

STEAMOTIVE

THE design and testing of a new type of steam-generating unit of good efficiency, relatively light in weight, and requiring a minimum of space, was described jointly by three well-known concerns at the annual meeting of the American Society of Mechanical Engineers, in New York City on November 30, 1936.

The new steam-generating apparatus has been named the Steamotive. In it, steam is generated at high pressure and temperature with fully automatic control. The units are intended for capacities of from 2000 to 10,000 horsepower.

Two such units have already been built. The first, now in service at Lynn, Mass., is used to test marine and other small turbines. It has an output of 21,000 pounds of steam per hour at a pressure of 1500 pounds. Another, incorporating the Steamotive and turbine-generator, with a capacity of 10,000 pounds per hour and furnishing steam to a turbine at 1200 pounds per square inch and 950 degrees Fahrenheit, is being installed in a small, isolated plant of a large industrial concern to supply electric power and low-pressure steam for building heating. Both are oil-fired.

Objectives sought in the design of the new equipment were high steam pressure and temperature, minimum weight and size, wide range of capacity with ability of the unit to respond quickly to wide variations in load conditions, adaptability to wide range of fuels, completely coordinated automatic control, and units of simple design constructed in portable sizes.

The Steamotive boiler was designed and built at Barberton, Ohio, while the meters with complete automatic control were designed and built in Cleveland. The auxiliaries, which supply fuel, air, and feedwater, are controlled in accordance with demands for steam. The auxiliaries, geared together as one turbine-driven unit, as in the case of the unit at Lynn, consist of a fuel-oil pump, a lubricating-oil pump and a feed pump delivering 25,000 pounds of water per hour with 60 inches of water pressure. The complete Steamotive unit was designed and constructed to be suitable for installation in a locomotive in conjunction with a turbine-electric drive.

In the operation of the Steamotive unit, the flame and gases pass from the burner through the completely water-cooled furnace and into the super-heater, flowing around the separator through the economizer and air heater, and up the stack. Air for combustion leaves the blower at a relatively high pressure, passing through lanes intersecting the stack, and down around the air-heater tubes to the oil-burner. There is no induced draft fan since the blower forces the air through the burner and furnace under pressure.

The feedwater enters the economizer inlet header, and, after leaving the outlet header, is divided into several circuits, all of which form the floor, sides, and roof of the furnace. All the steam is generated in these furnace and boiler circuits, and enters the separator with a surplus of water in each circuit. From the separator, the dry steam goes through the superheater, and directly to the main turbine. The water from the separator is called the spillover, and it passes through a heat exchanger to the hot well, where it mixes with the condensate, and is re-fed to the boiler by the feed pump. Because of the compact arrangement of the Steamotive unit, it constitutes what is practically a packaged power plant.

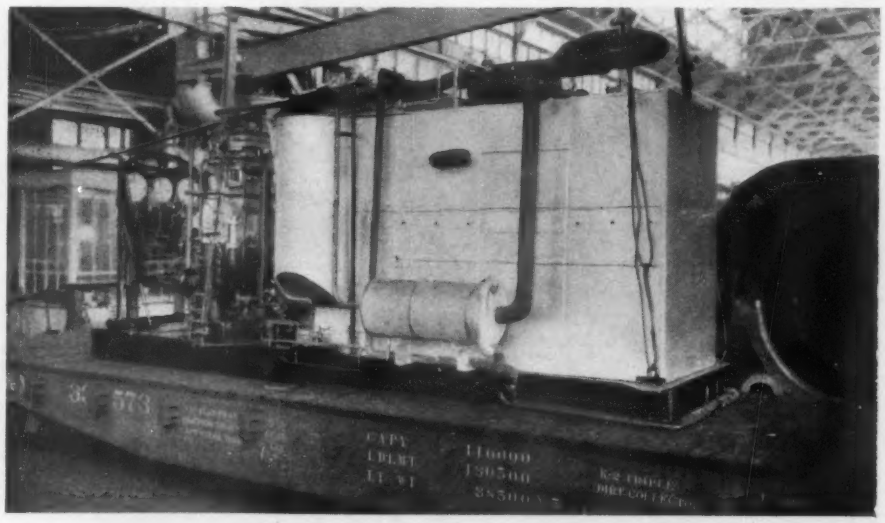
Two oil-fired units, each with a capacity of 40,000 pounds per hour, are now being constructed for a Pacific-Coats railroad for driving two 2500-horsepower locomotives, it was announced at the meeting. These units will furnish steam to the turbines at 1500 pounds per square inch and 950 degrees Fahrenheit. The units are compact enough to be shipped complete on a railroad flatcar.

—*General Electric.*

TOUGHENED GLASS

A glass that resembles plate glass, but has unusual properties has been recently manufactured in Birmingham, England. In one test an ivory billiard ball was dropped on a sheet of this glass from a height of 32 feet. The glass did not break, but the billiard ball showed flat "scars."

—*Machinery.*



THE WORLD'S FAIR

(*Continued from page 61*)

sightly young mountain of ashes stood above the Flushing river, men are today constructing the foundations for the $900,000 Administration building of the New York World's Fair.

Meanwhile, off to the sides of the lagoons, where it will not interfere with immediate Fair construction projects, is all that 800,000 cubic yards of meadow mat. This is destined to become an unusually fine grade of top soil to sustain the landscape effects planned for the Fair and the ultimate park.

Soil reclamation is being carried on in many parts of the world today, as it has been for centuries, but in practically all cases, whether in salt or fresh water areas, the reclamation of soil has been accomplished *in situ*. It is believed that the top soil project planned for the reclamation on Flushing Meadow, involving as it does the excavation of the material, is one of the largest of its kind ever undertaken.

The meadow mat, although it has great potential value as a source of top soil, is actually the "top" part of the marsh supporting a varied flora in rich profusion. Countless ages of fine silt and clay deposition built up the valley floor to a height where it would support marine plants. Generations of plants built up layers of organic material mixed with continued deposition of silts and clays, then a gradual changing of ecological conditions brought about a succession of plant life. Cat tails, rushes, sedges, reeds, salt marsh grasses, mallows, and groundsel shrubs have grown up, died, and dropped back into the ooze. Great quantities of decayed, and partly decayed, plant residues accumulated, finally, to form an organic, or muck, soil. This is overlaid with a densely packed mat of fibrous roots; the whole mat constituting a "top" one to three feet in depth. As excavated, this material comes away in unwieldy pieces up to a cubic yard in size.

Practical experiments during the summer of 1936 demonstrated that much could be done with the meadow mat whose long history had left it rich with the organic matter distinguishing fertile top soil from a mere mass of mineral fragments.

The organic content of the combined soil excavated will average about 35 percent by weight, as determined by loss on ignition of overdried samples. The minimum organic matter requirement in New York City and New York State specifications is six per cent. To raise the organic-matter content of one cubic yard of ordinary Long Island sandy top soil, by the addition of commercial humus or peat, to the high percentage contained in the Flushing Meadow material would cost well over one dollar, making due allowance for the increase in volume.

The New York Park Department has already prepared contracts for the removal of the stock-piled material from its present position by April 1 to areas where the natural weathering and other necessary processes can go on without interference with the Fair Corporation's immediate building program. It is expected that the handling of the matted "top" will accomplish some physical reduction and expose large surface areas to the ameliorating influences of aeration, alternate freezing and thawing, and wetting and drying.

When the material has been sufficiently affected by these natural processes, probably during the spring or summer, hydrate lime will be applied to effect very important physical, chemical, and biological changes, namely: to neutralize or reduce the acidity common to its source; to eliminate harmful chemical toxins or change them into less active combinations; to supply calcium as a plant nutrient and make other chemical nutrients more available to plants; to encourage beneficial biological processes; and to exert a flocculating influence on the puddled and impervious clay to encourage the formation of a more granular structure in the soil.

(*Continued on page 74*)

CAMBRIDGE ELECTROMETERS

● The application of Electrometers to the measurement of small electrical quantities has increased rapidly in recent years.

Among the more prominent Electrometer uses are researches in radio-activity, spectroscopic investigations and many uses in conjunction with photoelectric measurements.

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THE WORLD'S FAIR

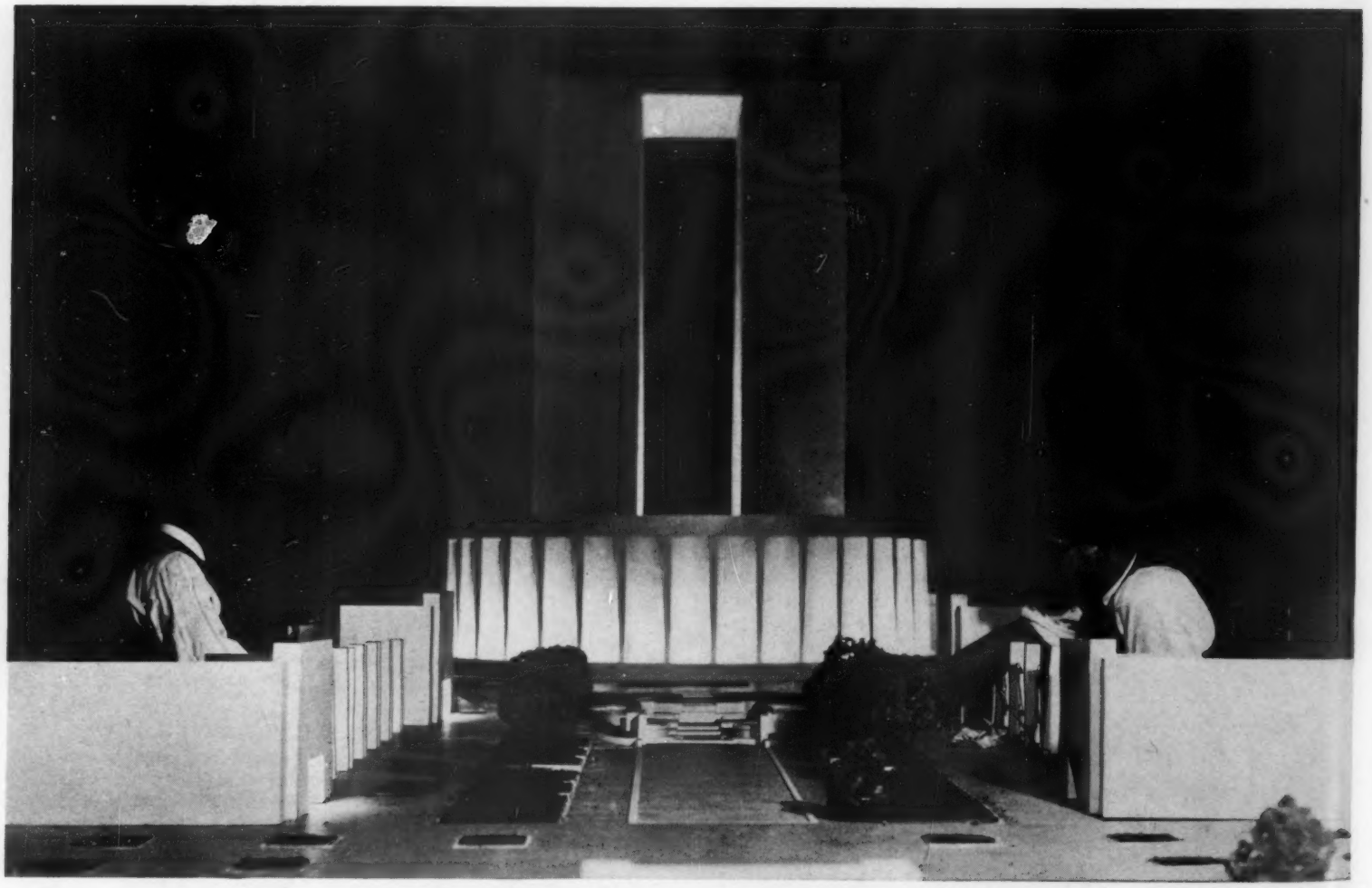
(*Continued from page 73*)

After addition of lime to the stock material, the fibrous portions of the mat and the lumpy portions of the muck will be reduced by mechanical means. This operation will further distribute the lime and organic material, and in so doing "fluff up" and aerate the whole, as well as causing fractures or lines of cleavage — thus tending to improve the soil structure by making it more granular, open, and friable. After the material has been "aged" with lime for a month, a final process will complete the soil reclamation.

For best results the high organic content of the soil must be in the form of humus. That is, it must be partially decomposed. Much of the organic matter in the excavated "top" is in this form, but also present are large amounts of raw, undigested organic matter. Before this can be of maximum benefit to plants of the higher order, it must be decomposed or simplified by bacteria and other soil organisms, which were lacking in the excavated meadow mat since almost all forms of bacteria cannot tolerate the highly acid condition common to the salt marsh. In order to speed up decay processes in the soil under treatment, bacteria and other organisms will be introduced by mixing the material with manure. After composting for three months, the finished soil will remain in stock piles until used by the World's Fair landscape engineers.

The Park Department's and the Fair Corporation's approach to the unusual method of top-soiling has been thoroughgoing — to the point where many an official can draw from his office desk a bottle of manufactured soil whose richness is apparent. The bottles are but one manifestation of the detailed study that has resulted in the transformation worked on the salt marsh tributary to the Flushing river.

Thoroughness does not stop with the creation of a fair grounds and its top soil. Thoroughness, it is obvious at the Fair Corporation headquarters, characterizes all activities, such as the study of tree-moving technique, the harmonizing of architectural designs, the consideration of hundreds of different construction materials, the laboratory testing of new principles in illumination, and even in the construction of toy-like models that are contributing much to the upbuilding of the science of display and construction.



Model makers setting up a section of the Fair preliminary to making illumination tests.

HISTORIC BUILDINGS

(*Continued from page 65*)

sion in a program recording interesting and significant specimens of American architecture" was submitted to the National Park Service. The subjects for measurement and photographing were to be "almost a complete resume of the builders art. It should include public buildings, churches, residences, bridges, forts, barns, mills, shops, rural outbuildings, and any other kind of structure of which there are good specimens extant. The list should be made up from the standpoint of academic interest rather than of commercial uses. The largest part of individual effort spent so far in measuring antique buildings and recording them seems to have been with an eye to adapting historic styles to modern commercial architectural practice, and whole classes of structure have been neglected." Also to be included were "other structures which would not engage the special interest of an architectural connoisseur — the great number of plain structures which by fate or accident are identified with historic events."

The plan proposed the employment of 1200 persons, of whom nearly 1100 were to be architects, and a total expenditure of $448,000. The executive functions were to be carried on by local officers, advised by local committees of architects and historians, and reported to the Washington office of the Branch of Plans and Design of the National Park Service. The Washington office in its turn was to have the benefit of a National Advisory Board. The efforts of the whole group were to be directed to the gathering of material for the archives in the Library of Congress.

(*Continued on page 76*)

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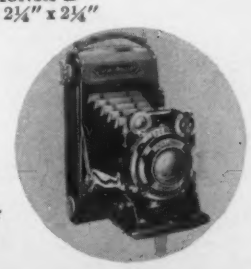

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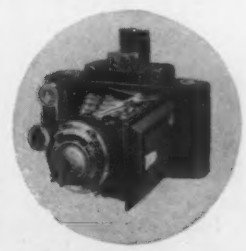
16 Negatives 1⅝" x 2⅛"



SUPER IKONTA D
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16 Negatives 2" x 2⅝"

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HISTORIC BUILDINGS

(*Continued from page 75*)

Immediately after its acceptance in November, '33, the project was set in motion by Chief Architect Thomas C. Vint of the National Park Service, assisted by Assistant Architects, John P. O'Neill and Dudley C. Bayliss. The Secretary of the Interior appointed District Officers and the National Advisory Board, in accordance with the recommendations of The American Institute of Architects. A nation-wide organization was soon functioning, and shortly after the first of the year measuring parties were in the field.

The project was carried on with the gratifying support of the profession and the public at large. By April it was possible to hold an exhibition, including drawings and photographs from all parts of the country, at the National Museum in Washington. The quality of the work was excellent, and the exhibition was well received. The proven feasibility of the whole idea encouraged the National Park Service, The American Institute of Architects, and the Library of Congress to effect, on July 23, 1934, an agreement to carry on the work as a permanent activity.

On August 21, 1935, there was approved an important Act of Congress "to provide for the preservation of historic American sites, buildings, objects and antiques of national significance, and for other purposes." This act declares this form of conservation to be a policy of the Federal Government.

Since the restoration of the Casa Grande Ruins of Arizona in 1889 and the setting up of the battlefield of Antietam in Maryland, and at Chattanooga in Tennessee, the following year, the nation has endeavored to preserve ancient and historic sites and buildings. In 1933, as a result of the President's Reorganization Order, the administration of all of the various historical projects was placed under the jurisdiction of the National Park Service of the Department of the Interior.

Among other things, the Act of 1935 directs that the Secretary of the Interior shall perform the following duties:

"(a) Secure, collate, and preserve drawings, plans, photographs, and other data of historic and archaeological sites, buildings and objects.

(b) Make a survey of historic and archaeological sites, buildings, and objects for the purpose of determining which possess exceptional value as commemorating or illustrating the history of the United States.

(c) Make necessary investigations and researchers in the United States relating to particular sites, buildings, and objects, to obtain true and accurate historical and archaeological facts and information containing the same."

The Historic American Buildings Survey made an impressive start in these activities, beginning nearly two years before the Act of August 21, 1935, under the broad authority of the NIRA. It might be appropriate here to define the

(*Continued on page 77*)

"Claremont," in Surry County, is one of the oldest important houses in Virginia. The exact date of its building is unknown. Part of the original estate of 1200 acres, patented in 1649 by Arthur Allen (a member of the House of Hanover), it was acquired in 1928 by General William H. Cocke. William Lawrence Bottonley, Architect, was in charge of the restoration.

HISTORIC BUILDINGS

(*Continued from page 76*)

nature of the survey, since its name, selected in the beginning for its trademark value, as Mr. Peterson states, has always been something of a misnomer. The product of the Historic American Buildings Survey consists of four parts:

(a) A master list of American buildings significant for their historic and architectural value, available in the Library of Congress.

(b) A collection of measured drawings of these buildings on standard sheets.

(c) A collection of photographs of these buildings, which becomes a part of the Pictorial Archives of Early American Architecture.

(d) A collection of historical notes deposited with the graphic material.

When the relief programs have ended it will probably be necessary for the Park Service to carry on the Historic American Buildings Survey by direct appropriation from Congress. An effective program of measuring could probably be handled by several squads working directly out of Washington, cooperating with the District Officers. Such parties would be able to reach many important buildings which have been inaccessible for measurement under the unemployment relief program because of insufficient travel funds. Field work of this type could be conducted by the government by means of outside donations, as well as by congressional appropriation. There are a number of individuals and foundations which have, in the past, generously endowed projects of a research nature, and it does not seem unreasonable to hope for support from such sources.

Architectural schools near historic buildings have a good opportunity to contribute records executed as a part of the regular training of the students.

Students of the University of Virginia are recording four of the original pavilions on the old lawn of the University campus. Pratt Institute has completed four measuring projects and is undertaking others. The University of New Hampshire, the Armour Institute of Technology, the Alabama Polytechnic Institute, Clemson College, and George Washington University have also made important contributions to the survey.

It is the opinion of the National Park Service, as an agency for the conservation of historic buildings, that all architects should file a complete record of the condition of any important building, before restoration or changes are allowed to be made in the structure. The facilities of the Historic American Buildings Survey could be utilized for this purpose.

It is hoped that the great archives begun by the emergency unemployment program will continue in its vigorous growth. The responsibility is shared by both the Federal Government and the architectural profession. The enthusiasm shown in the first two and a half years justifies the expectation of a long and productive future for the important work of the Historic American Buildings Survey.

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THE NEW UNIVERSE

(*Continued from page 63*)

Within the last year, plates extremely sensitive to infra-red light have been used by Hetzler at the Yerkes Observatory for discovering stars of such low temperatures as to be invisible by methods previously used. It seems not unreasonable that some of these emit scarcely any ordinary light at all. Their radiation is characteristic of that of a heated flat iron just beginning, or perhaps just failing, to glow.

A careful analysis of the spectra of stars, together with the development of the theory of ionization, made possible knowledge of the total light-emitting power and the temperatures of the surface of the stars of these several classes. Certain variations in the light of well-known stars in stellar clusters revealed a relationship between the absolute magnitude, or actual brightness of the stars themselves, and the period of fluctuation in the light of these so-called "variable stars." From an examination of many globular clusters of stars photographed at the Mount Wilson Observatory, Shapley was able to calculate the distances of these distant systems extending the supposed dimensions of the galactic system to a diameter of some 200,000 light years. The light year is a unit of distance; it represents how far light will travel in a year. It is roughly six million million miles.

Hardly had the dimensions of our galaxy become fairly well established before the huge telescopes were investigating the characteristics of the spiral nebulae which are distant systems far outside the galactic realm. With the 100-inch telescope at the Mount Wilson Observatory, Hubbell was actually able to resolve the great Andromeda nebula into individual stars, and to find among them cluster-type variables whose periods revealed their luminosity, thus enabling him to calculate distances to these exeedingly faint objects. The distance to the great nebula in Andromeda, the nearest of the extra-galactic nebulae, he calculated to be 900,000 light years. Thus, while the size and general form of our own galactic system is taking shape, revealing itself very much like a lens-shaped or watch-like aggregation of suns, astronomy has already begun the exploration of universes beyond our own.

Meanwhile, from the shift of the lines in the spectra of the stars betraying their velocity, the rotation of our whole galactic system has become established; a rotation about a center that appears from our earth to lie not very far from the region of Sagittarius in the Milky Way. The sun takes its place somewhere near, but not in, the central plane of this watch-shaped galaxy, and roughly half-way from the center towards the periphery. In common with many other stars it circulates about the galactic center, carrying its planetary system with it, at, such a speed as will enable it to complete a revolution in some 250,000,000 years. The accumulation of star positions and their comparisons with the earlier records give reasonable confirmation for this circulating drift of the astral bodies.

When the shift of lines in the spectra of the extra-galactic nebulae, came to be measured, it was found that, with fewe x-ceptions, these remote spirals all appeared to be receding from the earth at velocities increasing with their distance, aggregating speeds up to 20,000 kilometers per second. The idea that thousands of spiral nebulae should all be running away from us, as though they held some particular aversion to our own stellar system, seemed at first too ridiculous to merit any reasonable explanation. Meanwhile, however, the mathematical theory of relativity had been progressing, and new theoretical models of the universe came to light almost overnight from the hands of the mathematicians. Einstein, De Sitter, Le Maitre, and Eddington have been outstanding exponents in this field of theoretical investigation. Considered upon dynamical grounds with the postulates of relativity as a working basis, it was found that a universe of stars might of itself be expanding or contracting in accordance with the nature of the assumption of a certain cosmical constant, "lambda," that enters the equations. Since the observational data from the telescope indicate the recession of the remote nebulae, and a recession that apparently increases with distance, it was natural that the value of this mathematical constant should be so taken as to fit the observational picture. We have had, therefore, for some time, as one of the most fascinating doctrines in the new universe of today, the theory of a continued expansion. In such a picture every stellar system and every spiral nebula would appear to be increasing its distance from every such similar object, no matter what the vantage point of our observations might be. As the printed letters on the festive toy balloon increase their size and distance from one another while the balloon is inflated, so indeed by this crude analogy we picture the stars and galaxies increasing their distances from each other with the inflation of the universe itself. Here is a doctrine of inflation involving other than economic worries!

Some scientists, however, have oftentimes sounded notes of caution in the acceptance of the theory of the expanding universe. We must remember that there are other solutions of the cosmic equation. The solution which favors the expanding universe theory was adopted because it seemed to be the one

(*Continued on page 79*)

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THE NEW UNIVERSE

(*Continued from page 78*)

which fitted best the interpretation of the shifting of the lines in the spectra of distant nebulae towards the red end of the spectrum. This we have previously explained is what will happen if an object is rapidly receding from the observer. On the other hand, if we were ever to entertain the idea that the frequency in the vibrations of the light waves from remote objects slow down after thousands of years of journeying through interstellar space, this lowered frequency would produce precisely the same effect in shifting the lines in the spectrum towards the red, as would be the case if these remote objects were actually running away from us.

Within the last six months, Professor Haas of Vienna has astounded the scientific world with calculations in regard to the total amount of energy contained in the universe. The outcome of his calculations indicates that there is not enough energy within the universe to create any such expansion as has been postulated. He has shown mathematically that there is not enough energy in each gram of matter to have enabled the universe to have grown to double its original size. To double distances between nebulae scattered uniformly in space would require, according to Professor Hass, about 1,300,000,000 years. While this seems perhaps to many of us an inordinate amount of time, it is not so very long in a scale of cosmic evolution. From a careful investigation of radioactivity within the crust of the earth, the age of our own planet has been rather definitely established at at least 2,000,000,000 years. Since, then, the earth is here, and has been here for 2,000,000,000 years, it appears that there has not yet been time enough during the age of the universe for it to have doubled itself in size. According to Professor Haas, it does not contain enough energy to have done this even if it had so desired.

With such a bomb-shell thrown into the expanding universe theory, perhaps some physicist will yet be able to venture an explanation in which radiation loses energy in passing through interstellar spaces so that it is accompanied by a reduction in the frequency of the electromagnetic waves bringing light from remote regions. A note of caution has already been sounded. At the moment we are in a dilemma. We have no theory for a change in the frequency of light with distance, and we find difficulties in accepting an interpretation of a changed frequency that demands recession of the nebulae. If recession is the answer, then observations indicate velocities of expansion that, if Professor Haas is right, are quite untenable.

Such, then, is the picture of the universe that the mind of man has created out of innumerable observations that have come down from the ancients to modern time. Yet it should be recalled that from the dawn of astronomy to the middle of the eighteenth century, practically the entire time of both observational and theoretical astronomers was spent in the solution of our own planetary system and the earth's motions. Only a little more than the last century has been devoted to the astronomy of the stellar systems. Most of our knowledge of the galaxy and the extra-galactic nebulae has been uncovered in only the last two decades.

In closing the picture of the new universe, it is perhaps well to come back from the remoter regions to the planet on which we live, and to try to make out of the picture such significance as the universe may offer for those of us who are imprisoned for our lifetime on the planet Earth. While science

(*Continued on page 80*)

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THE NEW UNIVERSE

(*Continued from page 79*)

has been pursuing, with its increasing measuring-rod, the interstellar spaces, science has, at the same time, brought to light much new knowledge in regard to our immediate cosmic environment.

After all, probably the one star in the galaxy of galaxies that concerns mankind more than any other is the sun. In it we literally live, move, and have our being. The sun is the closest to us of all stars, so near in fact that we see it as a full orb rotating on its axis. Through the telescope we watch in detail changes in its outer atmosphere. Yet, even so, we know all too little about some of the mysterious problems that concern it. The sun has definite cycles in its behavior as evidenced by the growth and decay of sunspots in approximate intervals of eleven years' duration. Measurements of the heat and radiation of the sun at the Smithsonian Observatory during the last few decades have indicated that the sun itself is a variable; that it sometimes sends us more heat and sometimes less heat. Furthermore, the quality of the radiation in sunlight appears to vary. The ultraviolet light from the sun—at least, that part of it which penetrates through the earth's atmosphere and is so necessary for the health of mankind—undergoes periods of fluctuation which appear to follow the eleven-year solar cycle. The ultraviolet light of the sun striking the upper regions of the stratosphere so electrifies it as to produce a sort of ceiling that reflects the electromagnetic waves of radio. Observations over the last ten years indicate that this ceiling periodically rises and falls in accordance with the outbreak and disappearance of spots on the sun's surface. Since the performance of your radio set, particularly as regards distant reception, depends upon the reflection of radio waves sent skyward, changes in the quality of distant radio reception follow markedly changes in the sun's performance. One would venture to say that here is a new tool for the solar astronomer. Unlike light waves, radio waves penetrate the clouds so that suitable radio equipment may yet make it possible to discover what is happening on the sun even through the sun itself were obscured by clouds for a long period. Disturbances on the sun itself are accompanied by disturbances in the earth's atmosphere which give rise to displays of aurorae, most frequently seen at times of sunspot maximum. The very air which we breathe is electrified or ionized. Some would have us believe that these ions in the lower air affect us physiologically in some mysterious way. Whether or not ions in the lower air vary with the number of ions in the upper atmosphere produced by the ultraviolet light of the sun, we do not know. We are investigating. Furthermore, millions of ions are continually being created in our atmosphere by the incoming cosmic rays, that penetrating radiation whose origin is still much of a mystery. Are these cosmic rays high-speed electrons shot earthward from the remoter regions of space; or are they photons, light pulses of exceedingly penetrating wave length, even shorter than that of X-rays? Calculations by Millikan and others appear to establish definitely that they cannot be of atmospheric origin, but have energy indicative of that released from the transmutation of elements. Four hydrogen atoms have the building materials for one helium atom. If, somewhere in the remote regions of stellar space, they should decide on the creation of one such helium atom, they might coalesce, build an atom of helium, and scatter enough left-over energy to account approximately for the energy in the more penetrating cosmic rays. Thus, Millikan has suggested that cosmic rays are the "birth cries of atoms" being born in interstellar realms. On the other hand, Jeans suggests that if atoms should suddenly annihilate themselves, the energy which would be released by the disappearance of their mass would be about equal to that of some of the cosmic rays. And so in equally poetic and sadder language, Jeans would have us believe that cosmic rays are the "death cries of atoms" passing into oblivion.

In looking into the future of science and our knowledge of the universe in the coming decades, I would venture to predict that we will see advances along two frontiers leading in two very different directions: 1) extending our knowledge of the remoter regions through the creation and completion of the 200-inch telescope in California, and 2) extending knowledge of our immediate cosmic environment in space, tracing certain mysterious changes in the earth and its atmosphere and perhaps even in its biological realm to changing conditions outside the earth itself. It already appears that periodical changes in the sun are responsible for more far-reaching consequences in the affairs of the earth than we have perhaps been inclined to suppose. The field of investigation into cosmic and terrestrial relationships is just beginning.

New findings, already modifying our views of the physics of the earth and its atmosphere, and even life itself, lead me to believe that in these directions the greatest contributions of astronomy to human thinking are yet to be made.

RESEARCH IN REVIEW

(*Continued from page 69*)

A small but powerful electromagnet which has produced 75,000 gauss was reported by Dr. Francis Bitter.

A compact 1,000,000-volt electrostatic type generator was installed at Huntington Memorial Hospital, Boston, to produce radiation useful in cancer therapy.

First complete x-ray analysis of the atomic arrangement of an amorphous substance (glass) was obtained by Professor Bertram Warren, '24.

Quantitative treatment of convection in the interior of the earth was initiated by Dr. C. L. Pekeris, '29.

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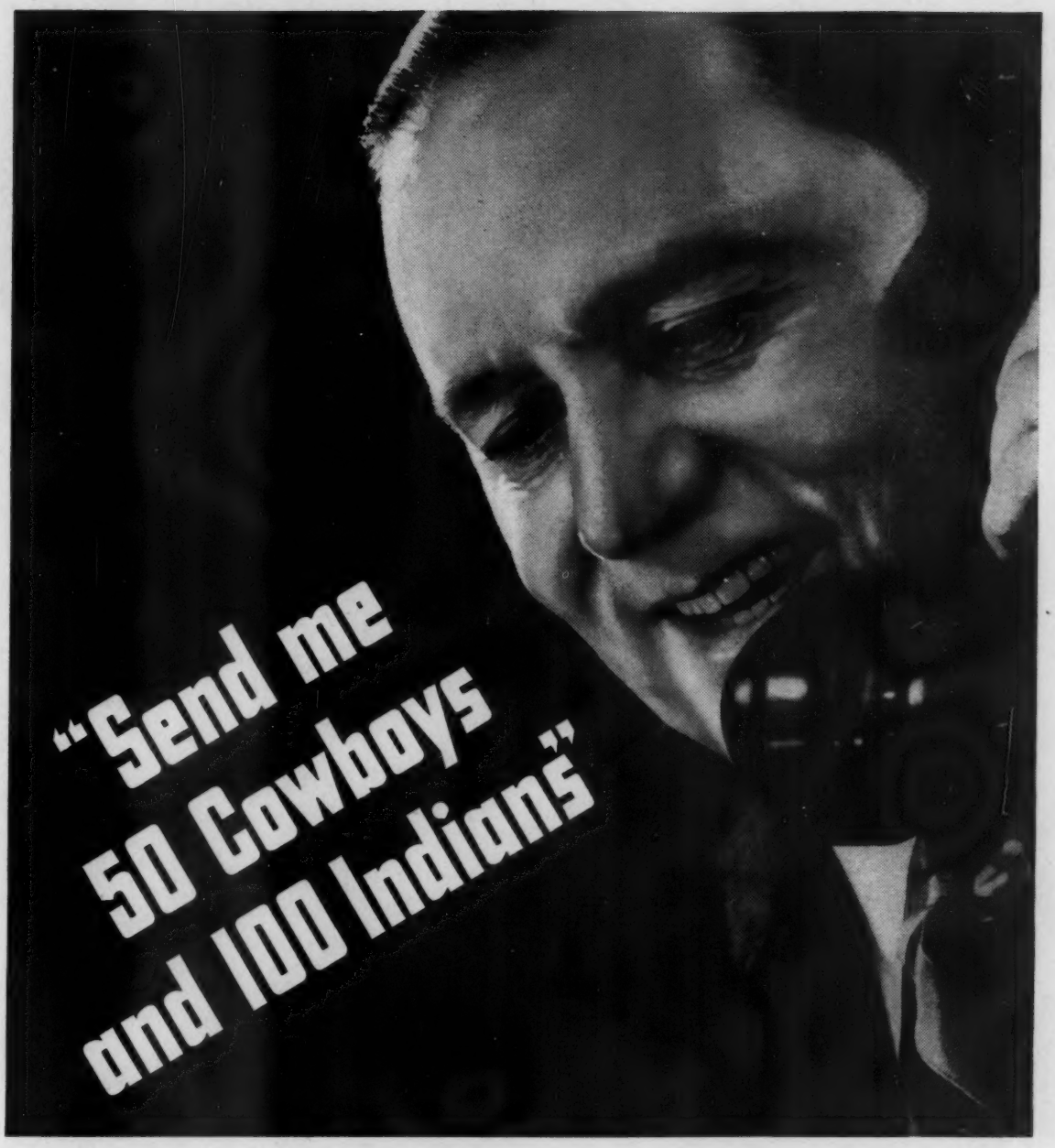

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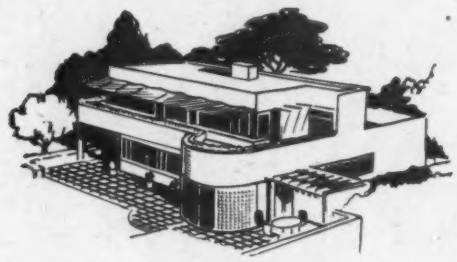
G-E *Campus News*

IN EVANSVILLE

Into the flood zone several General Electric engineers—among them Henry Duval of Washington University, Eugene Darlington of Oregon State, and Harold Towlson of Clarkson Tech—took two radio-equipped police cars and played an important part in the relief activities along the Ohio Valley. The equipment included a two-way ultra-short-wave police radio set in each car, a 50-watt headquarters transmitter, and a 150-meter transmitter having its own gas-engine-driven electric generator—in reserve in case of power failure.

One of the engineers reported, "We arrived in Evansville and erected our antenna on the 75-foot tower of a bank building. We were on the air continually, rendering service to the flooded area."

In a further effort to aid flood victims, General Electric sent extra men to the G-E Service Shops in the affected area to speed repair work.



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